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A dash into the enemy's lines

AMERICAN ARMORED MOTORCARS [See page 388]

The Science of Naval Architecture*

A Review of Some of Its Fundamental Principles

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THE art of shipbuilding was undoubtedly developed at a very early stage of the history of the human race. The earliest record of a ship, as distinct from a boat, canoe, or other small craft, is found in Egyptian carvings of a date about 3,000 B. C. But the Science of Naval Architecture, like so many other branches of science, developed slowly; this science, as now accepted, being mainly a development of the last hundred years, we may almost say of the last fifty years.

The famous Swedish Naval Architect and Shipbuilder, Henry De Chapman, published a treatise on shipbuilding in 1775. As late as 1820, we find Dr. Inman, the head of the Royal Naval College and School of Naval Architects, in Portsmouth Dockyard, England, publishing a translation of Chapman for the instruction of English students of Naval Architecture. Chapman's work, so far as it deals with the science of Naval Architecture, consists largely of empirical rules, although it was far in advance of his day, and much of it is still applicable to sailing ships. In some respects his ideas were largely erroneous, an example being his theories regarding resistance of ships. In fact, it was not until a hundred years after Chapman's time that the science of Naval Architecture was enriched by sound theories concerning this important branch.

Dealing with the sailing vessels concerning which Chapman wrote, Ruskin said:

"Take it all in all, a ship of the line is the most honorable thing that man, as a gregarious animal, has ever produced. By himself, unaided, he can do better things than ships of the line; he can make poems and pictures and other combinations of what is best in him. But, as a being, living in flocks and hammering out with alternate strokes and mutual agreement, what is necessary for him in those places, to get or produce the ship of the line is his first work. Into that he has put as much human patience, common sense, forethought, experimental philosophy, self-control, habits of order and obedience thoroughly wrought handiwork, defiance of brute elements, careless courage, careful patriotism, and calm expectation of the judgment of God as can well be put into a space 300 feet long and 80 feet broad, and I am thankful to have lived in an age when I can see this thing done."

This is what Ruskin thought and wrote years ago of the ship of his day. His words are even more true of the ship of our present day and generation. His 300 feet of length has trebled, and the size of such a ship, as measured in terms of weight, has grown nearly ten times. These modern ships have been made possible by the development of the science of Naval Architecture. This science alone and unaided, without parallel development in practically all of the arts, sciences and trades, could not have produced these ships; but so far as the ship itself is concerned, all the great progress in every branch of science and industry could not have produced this concentrated embodiment of human intelligence without the development and advancement of Naval Architecture or the theory of shipbuilding, a branch of applied science which calls upon and draws from an exceptional number of the arts and sciences.

The modern battle-cruiser, whose building is just being undertaken in this country, is an excellent example of the mutual agreement and coördination necessary between all the arts and sciences in the work of the Naval Architect. These vessels of ours will be of 35,000 tons displacement, and will be capable of a speed through the water of some 35 knots, or a little over 40 statute miles per hour. To drive this mass at this speed there will be required a machinery installation capable of delivering 180,000 horse-power. The vessels are 850 feet in length; they will carry ten high-powered 14-inch guns as a main battery, with the addition of a large number of guns of smaller caliber, to say nothing of torpedo tubes. Let us consider very shortly a few of the sciences involved when we undertake to build such a vessel. It is hardly necessary to say that this undertaking would not have been possible without the slow, steady development, through the ages, of the various theorems of pure mathematics, which, in their applied forms, have been necessary to material progress in the various branches of engineering. In addition to its general application, mathematics has made possible the modern systems of control of the firing of the great guns, which permit them, with a considerable degree of accuracy, to drop a shell, weighing a ton, on a comparatively small target, at a distance of twelve to fifteen miles. This accurate control of fire is based largely on instruments or mechanisms which permit the instantaneous solution of problems containing as many as half a dozen variables.

Likewise, these ships could not be possible without the aid of astronomy, for it is through the development of that science, and through the experimental results made possible by it, that the various navigational instruments can be utilized to permit a sure and safe passage of the ship from one point of the earth's surface to another.

Chemistry has played its part, not only in its general contributions to all enginering progress, but also in its solution of specific questions and difficulties, such as are involved in the manufacture of propellent powders and high explosives in forms that may be safely handled and carried on such a vessel until the selected moment for turning loose their destructive forces. Chemistry, also, through its particular manifestation in the form of metallurgy, has played one of the most important parts by providing numerous varieties of steel, ferrous alloys, and non-ferrous metals, which are used in the various parts of the ship and its equipment, many of these having been developed solely for the use to which they are put in such vessels as these.

Physics, in its various branches, has played a prominent role. In optics, it has given us the theories of, and has made practicable the various instruments, which, in conjunction with fire control systems, make possible the accurate firing of guns and torpedoes, without which such a vessel would have no *raison d'etre*.

Acoustics has played its part in the solution of many particular problems and difficulties, for, in the same way that coördination has been carried out in constructing the ship, the most complete and harmonious coördination of all parts of its organization are necessary in her hour of trial by battle.

This is rendered possible only by the most perfect means and instruments of communication throughout all parts of the vessel. These systems of communication must be such that they will not break down in the midst of the noises and confusion of battle, or because of the high mental tension, at such times, of the personnel using them.

The sciences of Physiology, Medicine and Hygiene must likewise play their parts, for, during the long years of peace, each of these vessels must be the healthful and as far as possible, the happy home for anywhere from 1,000 to 1,500 men. This means that what we term in the Navy "berthing and messing" facilities, or, what in civil life would be referred to as the "housing and feeding" conditions, must be based on the most modern scientific principles. Likewise, to insure efficiency in battle, the design must take careful cognizance of what these sciences have taught us as to the limitations on human endurance when working at high pressure under adverse conditions. Nor do we stop at this point, for, there is provided, in addition, a completely equipped medical establishment, or hospital, including operating rooms, isolation wards for contagious diseases, special examining and treatment rooms, dental facilities, etc.

Without further enumeration of the many other branches of science and engineering which necessarily enter into the design of one of these great ships, let us consider more closely the principal branches of Naval Architecture proper. This is, broadly speaking, the division of engineering which enables us to make use of accumulated progress and knowledge to produce one workable and efficient assembled unit in the form of a ship. Its branches closely parallel the primary operations necessary in the design of such a ship, as has been described. Given the fundamental requirements of the design which, in the Naval Service we term the military characteristics, and which consist of a brief statement of the results which it is desired to obtain with the completed vessel in service, it is first necessary to make an estimate of the size of the ship which will permit a solution of the design problem. This first estimate or approximation must be based largely on previous practice and experience. Before the development of Naval Architecture in its modern sense, the necessity usually involved rather slow step-by-step progress from one ship to another. Naval Architecture has now taught us how to make these steps much greater, so that during the last quarter of a century advances which would have been bold to rashness at an earlier time, have become almost routine. The rule of step-by-step progress referred to above has at least one remarkable—we may almost say astonishing—exception. Some sixty-five years ago a famous English civil engineer and bridge builder turned to shipbuilding. Maintaining that the larger the ship the more economical and efficient her operation, Brunel attracted large capital and in association with Scott Russell, the shipbuilder and naval architect, finally produced the "Great Eastern," which was indeed a giant by a pygmy when compared with the other iron steamships of her day. Her keel laid in 1854, launched in 1858, after many difficulties, and put in service in 1859, the "Great Eastern" was not a commercial success. She fell short of the expectations of her designers in many respects. The successful completion even in five years of such a vessel was truly a remarkable accomplishment, but her size was ahead of her day, and it was not until 1899 that we find it again reached. As already stated, progress is more rapid nowadays than heretofore, but even now Naval Architecture would hardly enable us to take, with confidence, such a leap as the "Great Eastern" promoters undertook.

When in the early stages of a design we have, based on previous practice and experience, reached a first approximation to the size of the vessel, it is next necessary to examine in detail the problems of strength, stability, resistance, and propulsion of the ship. These represent broadly the main divisions of our subject. Naval Architecture, as a whole, and its branches, like engineering, generally, has not yet become an exact science, and in some respects, it appears impossible that this will ever be attained. The strength and stability of ships, for example, should be such as to enable them to withstand, under all conditions, the waves of the sea, but the latter are infinite in variety, and the attempt must be to provide for any manifestation arising from this variety. It is, therefore, not impossible in a new problem to lay down an exact condition of water surface, and say that if our ship can stand this condition, it can stand all others. The best we can do is to make an approximation of the most severe condition, based on previous accumulated experience and observation. There have been made many thousands of observations on sea waves, but there is yet no complete agreement in regard to their limiting characteristics, such as length, height, and the relations existing between these dimensions.

About the middle of the last century Rankine gave us the first complete mathematical theory of the formation and character of waves, known as the trochoidal theory; his result had, however, been largely predicted by Grestner more than sixty years before. Although Rankine's theory does not explain, and is not entirely consistent with all phenomena of this nature, it is generally accepted today as a reasonable and convenient approximation of the facts and it is usually upon stresses due to waves such as result from Rankine's theory that we have our determinations of strength of vessel.

We find that from the very beginning of practical shipbuilding, the problem of strength was recognized in concrete form, for in the very first ship of which we have historical record, its picture shows what we now term a "hogging" girder, which was provided to take the strains resulting from the variation between distribution of weight and distribution of buoyancy. It was the existence of these strains, and the fact that they increased with increase in length of ship, that operated to limit the length, and, consequently, the size of ships during the era of wooden shipbuilding, as it was then, and still is impracticable to develop the full strength in end connections between contiguous wooden members. The introduction of iron and steel, in conjunction with the development of methods and mechanisms for riveting has made the modern ship possible. For many years, the provision of the necessary strength depended largely on rule-of-thumb methods, and step-by-step development from one ship to another. Such methods, of course, led in the majority of cases to one of two results; either deficiency of strength, or excess of strength. For any structure erected on shore, the latter fault is not necessarily a serious one, except from the point of view of cost. On a ship, however, too much material is almost

*Presented at the stated meeting of The Franklin Institute held Wednesday, May 16, 1917. On this occasion the Franklin Medal was presented to Mr. Taylor in recognition of his fundamental contributions to the theory of ship resistance and screw propulsion, and his success in the application of correct theory to the practical design of varied types of war vessels in the United States Navy.

as grave an error as too little, for every ship is built to perform some distinct service, and as a floating body, can only carry for all purposes the equivalent of the weight of water which it displaces. Every pound which goes unnecessarily into the structure of the ship itself is a dead loss to the aim or object for which the vessel is designed. The modern theory of longitudinal strength for a vessel, as based on many years of observation and experiments, has its origin in the simple fundamental theories of strength of beams or girders. The ship's structure as a whole is considered as a built-up girder with upper and lower flanges and connecting webs. This girder is assumed to be supported on a wave of length equal to that of the ship. The height of this wave is assumed to have various relations to its length, depending upon the magnitude of that length, but for the majority of cases, this relation is taken as one to twenty. This girder is then assumed to be supported in a manner represented by the buoyancy curve of the ship when floating on such a wave. The form of this buoyancy curve will, of course, vary with the position of the ship in relation to the crest and hollow of the wave, and in important strength calculations, it is redrawn for at least two, and sometimes as many as six positions. The loading of the girder is represented by the loading of the ship, including its own weight, that of permanent installations, such as propelling machinery, etc., and that of the variable or useful load carried. By successive integrations and the use of the simple beam formula, we then arrive at the figures representing stresses and strains in the theoretical girder. Some experiments have been made from time to time, notably those of Biles in 1903, to check the accuracy of the results obtained by this method, but due to the cost and magnitude of such experiments, there has never been collected sufficient data to enable us to say how accurately these results do represent the actual stresses in the ship in service. Accordingly, we are still largely dependent on comparing the figures obtained by this method for the new ship with those obtained by the same method for previous ships that have shown adequate strength in service.

Possibly due to the fact that our standard wave is not so steep as waves having the length of short ships, and steeper than waves having the length of long ships, it seems to have been thoroughly established by experience that, with the method outlined above, it is safe to allow larger stresses in large and long ships than in short and small ones. If for instance we find that by this method a small vessel in service shows satisfactory results when her figured standard stress is, say, 6 tons in compression and 8 tons in tension, and shows indication of weakness if these figures are materially exceeded, we would find that also in service a very large and long ship would show no signs of weakness with calculated stresses as high as 10 tons in compression and 12 tons in tension. This principle appears to have been acted upon, though the scientific principles underlying it were not fully understood, even in the early days of iron shipbuilding. This was brought out about 50 years ago, when our modern methods of figuring strength was first applied to ships built in accordance with the then existing rules of the classification societies, with the result that the large ships of that day were found to have indicated stresses in extreme cases nearly five times as great as those found in small ships.

There are, of course, a very large number of strength problems involved locally in ships themselves, and therefore particularly within the province of Naval Architecture, but these are after all secondary when compared with the problem of the strength of the main structure.

Turning now to stability, which is the measure of the ability of a ship to remain upright or to return to the upright when inclined by an external force usually impressed by varying conditions of water surface, we find that the full and exact treatment of this branch is of quite modern origin. In the earliest day, adequate stability was largely dependent on carrying ballast and the amount and location of such ballast was determined by trial. In other words, except by following more or less closely the model of a previous vessel, there was no means of determining in advance whether a proposed design would result in a satisfactory stability condition.

About the middle of the eighteenth century the French mathematician, Bouguer, made a long step in developing the science of stability by developing the conception of the metacenter. In mathematical language, the metacenter is the center of curvature of the locus of the center of buoyancy of the vessel as it is inclined. As a practical proposition, the metacenter is the limit above which we cannot locate the center of gravity of the ship without having her initially unstable and unable to remain upright. The position in space of this imaginary point depends upon the geometrical form and the dimensions of the ship. Perhaps a homely illustration may clarify the matter: If you take an ordinary rocking chair and attach a weight to it in such a manner that the center of gravity of the chair and the weight is above the center of curvature of the rocker, the chair will not stay put and will loll over and capsize. If the center of gravity is materially below the center of curvature of the rocker, which is the case when one sits in an ordinary rocking chair, the chair will remain in a fixed position; if the rocker is very flat, resulting in a greater distance of the center of gravity above the center of curvature, the chair will be stiff and harder to rock or heel from the upright position. The matacenter of a ship corresponds very closely with the center of curvature of the rocker as already described.

After Bouguer developed the conception and mathematical methods for calculating the position of the metacenter, Atwood carried the matter further by calculating the righting arm or lever, which, multiplied by the weight involved, measures the torque when a vessel is inclined. The metacentric conception applies only to initial stability with the vessel upright, and for many years appears to have been sufficient, particularly as applied to sailing ships, which were very much of the same general type, with comparatively small variations of general form, relative freeboard, etc.

Something more than fifty years ago, however, the loss of the "Captain" brought home very strongly to Naval Architects, particularly in England, the fact that there was another factor involved in stability. A distinguished English officer, Captain Cowper Coles, took up with enthusiasm the monitor idea, first developed by Ericsson in this country, and as a result of his campaign there was built in England a low freeboard vessel called the "Captain," with turrets and also full sail power.

Naval Architects of the English Admiralty were not enthusiastic over the type. The vessel had much less metacentric height than the pure monitor type, but early reports and experience with her indicated that she would be a great success, until on the night of September 7th, 1870, in the Bay of Biscay, with a moderate gale blowing, she capsized, with a loss of 481 lives, including Captain Coles himself. The vessel was perfectly safe until conditions were such that she heeled over enough to bring her deck edge well under water. After that, her righting force rapidly decreased, and at a comparatively small heel became negative, resulting in capsizing. Under the weather conditions existing the force of the wind against the sails of the "Captain" was sufficient to heel her beyond the safety angle, and over she went.

The investigation into this disastrous occurrence brought out the fact that a vessel with a comparatively small metacentric height may be perfectly safe if it retains a righting tendency at a large angle of inclination—a feature associated primarily with high freeboard. On the other hand, a low freeboard vessel, with a comparatively short range of stability, may also be perfectly safe if its metacentric height and initial stability are very great, so that a large amount of work has to be done to incline the vessel throughout its comparatively short range of stability.

This whole question is now fairly well understood, and the Naval Architect is enabled to adjust his metacentric height as he will by varying proportions and dimensions of the ship to suit the position of the center of gravity and type of vessel—all requiring very careful and detailed calculations. As a matter of fact, there are passenger vessels crossing the Atlantic in perfect safety, with no initial stability, or even with a slightly negative metacentric height, their freeboard and shape giving them a range of stability of as much as 90 degrees.

Since the days of Fulton's first steamboat, the design of vessels' hulls, on such lines as to give the minimum resistance in passage through the water at varying speeds, consistent with the other characteristics of the ship, has become increasingly important. This is well illustrated in the case of the new battle-cruisers, to which I have already referred. To arrive at the most advantageous dimensions and form of hull, for purposes of the high speed desired, there were made and tested in the Model Tank, at Washington, upwards of twenty models, with the result that the resistance of the model finally adopted was nearly 15 per cent less than that of the first model tried.

I would particularly invite attention to the fact, however, that this was by no means due to improvement in shape of lines alone, but also to other changes which were adopted with some reluctance, but which it was known in advance would materially reduce the resistance. Experience in recent years has fully confirmed the conclusion drawn from model basin investigations that, for high-speed vessels, the length is a primary factor. In fact, we know in the majority of cases of high-speed vessels that we could reduce resistance by increasing the length. This usually involves, however, increased weight of hull and other objections. So that for large, fast vessels the Naval Architect usually adopts dimensions which do not give the minimum resistance for the displacement, but the best all-around result considering the total weight, including both hull and machinery.

Men-of-war in particular are generally made relatively shorter than merchant vessels, for the reason that ordinarily they travel at a low speed, and the long vessel requires more power at low speed than the short vessel, and hence, on a given endurance, requires a greater weight of fuel. The merchant vessel, particularly the fast passenger vessel making its passages at top speed, or thereabouts, must be economical at that speed.

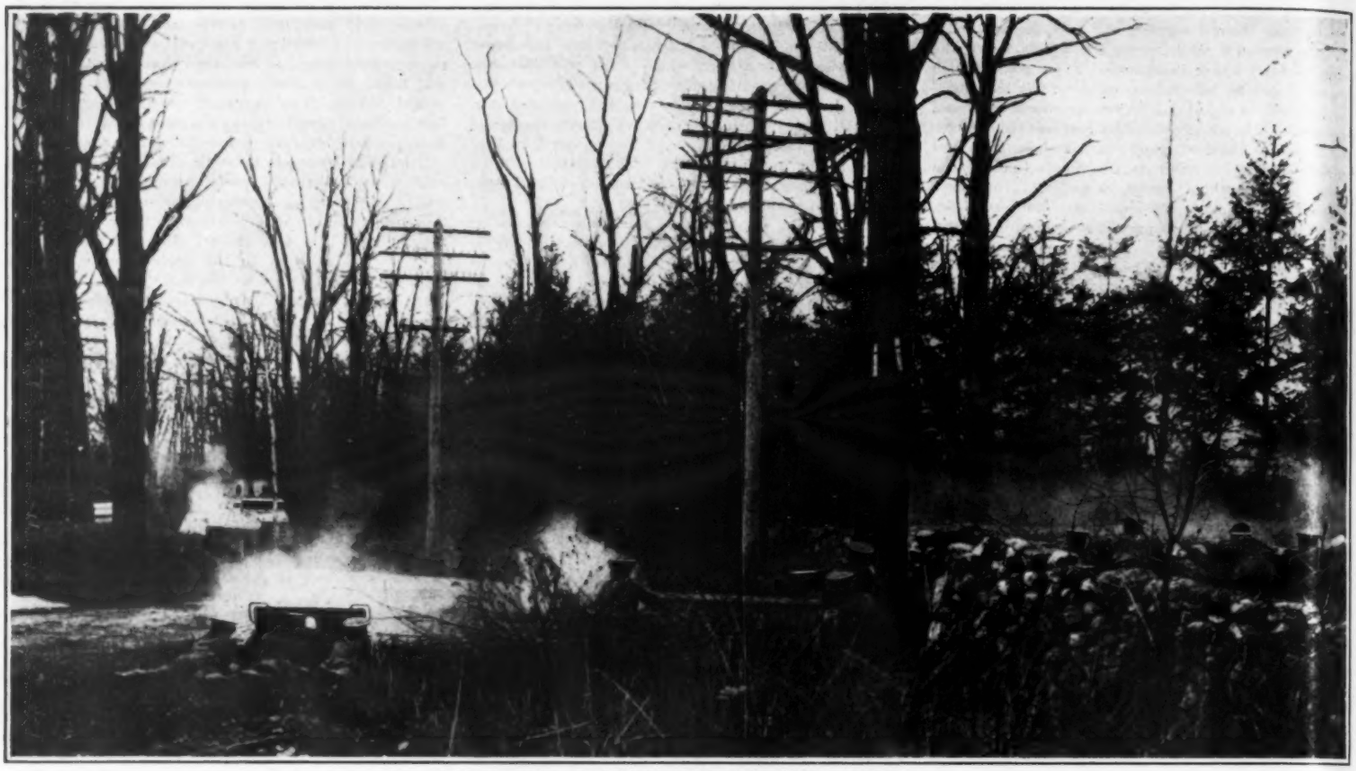
A hundred years ago the ideas of ship resistance were entirely crude, the usual opinion being that the resistance was in proportion to the area of the cross-section of the vessel which had to be forced through the water. About the middle of the last century, Rankine put forward a theory which went to the opposite extreme. His proposition was that in a well-formed vessel the resistance was entirely due to the friction of the surface against the water, and he developed a method for estimating this. Our modern ideas on this subject are due primarily to William Froude, the originator of modern experiments, which have been the most useful appliance of research in this line one could imagine. The "law of comparison," by which, from the resistance of a small model, at low speed, we can closely estimate the resistance of a large ship at high speed, is commonly called, by Naval Architects, "Froude's Law." It appears to have been originated independently by Mr. Froude, although, as a matter of fact, it is a particular case of the general law of mechanical similitude, apparently first enunciated by Newton.

The resistance of ships by the Froude methods is regarded as made up of three elements: The friction of the surface which, for low-speed vessels, may be as much as 90 per cent of the total, and seldom falls below 50 per cent even for very fast vessels; the wave-making resistance, due to the energy required to create and maintain a system of waves accompanying the motion of the ship through the water; and the eddy resistance, due mainly to eddies behind sternposts, struts, and other appendages, and hence quite a small factor in the total. The "law of comparison" applies with great accuracy to the wave-making resistance, and with reasonable accuracy to eddy resistance. To frictional resistance it is not applicable, but Mr. Froude, by experiments on surfaces, established coëfficients of frictional resistance which are used to this day, although for some time Naval Architects have felt that it would be desirable to revise these coëfficients upon the basis of experiments on a large scale. The procedure we use at the present time in obtaining the lines for a ship, is about as follows:

By the use of tables and curves which have been produced as the result of years of experiment, at the Washington Model Basin, certain coëfficients, representing a form of underwater body, are selected, as giving a close approximation to the best solution of the particular problem in hand. By the use of these coëfficients, we can arrive at approximation to the best dimensions for any particular ship, and by the further use of certain standard forms of waterlines, can draw, with little difficulty, the lines of the vessel. From the same data, we can obtain a close approximation to the resistance, at varying speeds, of a hull built from these lines. These steps permit of settling the broad general characteristics of the design. The lines so drawn are then sent to the Model Tank, where a model to exact scale is built, and its resistance accurately measured at varying speeds. In important designs, as in the case of the battle-cruiser, this model will receive many variations in shape and refinements of details, until it appears probable that the minimum resistance for such a hull has been reached. The resistance curve obtained from the final model is then used as the basis of the design of the machinery plant and propellers for the vessel.

There are, of course, many other divisions and subdivisions of Naval Architecture which enable us to foretell with a considerable degree of accuracy the behavior of a vessel under the many different conditions which may be met in a varied career of service, as for instance the degree of punishment which the ship can stand before sinking, when subjected to attack by gunfire, submarine torpedo, and mine and aerial bomb. These are factors which hitherto the Naval Architect has not been required to consider as regards merchant ships. If present piratical methods of war at sea are to continue, the distinction between merchant and war vessels will necessarily disappear.

As regards vessels of war, experience to date has shown broadly that the science of Naval Architecture has provided ships which function as anticipated. The enormously destructive weapons of the day are able to destroy in time anything that floats, and without disparaging Mahan's dictum that "good men in poor ships have always won over poor men in good ships," there is no doubt that good ships are essential even to the best men. Our ships are now to undergo the "trial by ordeal" of the features carefully and patiently planned in past years; may they prove worthy of the good men that man them.



An armored car attacking an outpost, in militia maneuvers

Armored Cars Being Developed in America

DURING the early days of the war armored automobiles, equipped with machine guns and riflemen, were quite a prominent feature in the fighting, but since the armies "dug in," and trench warfare prevailed, practically nothing has been heard about them, and it is not likely that they are now used in France, or on the Eastern front. In the Italian campaign against Austria fast armored cars were found very effective for scouting expeditions; and in Egypt and Mesopotamia such cars are still employed to great advantage.

Considerable attention has been given to the development of armored cars in this country, and a number have been built which have been tried out experimentally in militia maneuvers in several states. Our illustrations show some of these cars attached to the National Guard of New York State, and they are very promising wherever fairly good roads are available. But where the operations are as strenuous as the prevailing conditions in France and Belgium, the roads are probably too badly cut up to permit of their operation, and the heavy artillery that is so thickly planted in those regions would make a car equipped with light armor decidedly inefficient and the vulnerability of their running gear would be another serious disadvantage.

Collecting Tree and Flower Specimens*

By Dr. R. W. Shufeldt

AN invaluable aid in studying our wild and garden flowers is a good microscope, as powerful and standard a one as your purse can buy. You will not proceed very far into the field of even popular botany and wild flower study, before you find that it will require a stronger eye than the one you have in your head ere you can accurately discern all there is to be seen in a flower. Some of the modern microscopes are superb instruments; not only are they great and accurate magnifiers of minute structures, but they admit of the use of special accessories, so that one can either draw or photograph the object under examination. There are many types of fine and inexpensive microscopes on the market, which are almost indispensable to begin with, while the high-powered ones can be commended after the student is satisfied that the study will be with him as long, perhaps, as he lives.

The forming of a working, scientific herbarium is another step in the study of flowers and it is quite a task, and requires special knowledge along a variety of lines. In the first place, you must know how to collect scientifically: to select in the field, or in nature, to speak more broadly, the class of material worthy of your care, and measuring up to what the specimen demands in any case. Always select the most perfect specimens, from root to flower. Keep collecting until the entire life-history of the plant is completely illustrated. Show the normal as well as the abnormal, and all the necessary variations of all the structures of any plant you bring in. Take leaves, for example: of course the forms assumed by them are infinite, even for the same species. Still we may, by judicious selection, very well illustrate the limits in any direction with a very few examples. A good way to study such a point as this, is to select some big oak tree, standing so far in the open that there is no danger that its fallen leaves in the autumn have become mixed up with those from any other tree. You will be surprised at the number of forms the leaves seem to have; yet, when you have judiciously collected forty or fifty of them and arranged them in a row in your study, how few it requires to actually illustrate, not only the variation but also the fact that the leaves belong to that particular species of oak, provided the tree you selected was not a hybrid.

You must collect your flowers, seeds, seed-pods, roots, buds, and all the rest, in the same scientific manner. Collecting-boxes for use in the field can be obtained at any first-class naturalists' supply establishment, anywhere from fifty cents to two dollars and a half. Get the best every time. There are also admirable contrivances for the pressing of flowers manufactured, with instructions for using them, such as Riker's Botanical Press; wire presses, and plant presses of various models; all are excellent as well as indispensable.

In pressing flowers one must use every bit of one's scientific and artistic sense, in order that the pressed specimen shall exhibit every point and character it possesses, and every point one desires to show. One should likewise be familiar with all that is known up to date with respect to preserving the color of flowers, leaves, and other plant-structures during their pressing and preparation for permanent preservation.

In the summer, after any of your specimens are pressed, you may consign them to temporary folders until your winter work and studies come around. The larger magazines may be pressed into service for this purpose, while the chief thing to be attended to is to see well to it that your stack is kept in a dry place with a proper weight on it, and where no one will handle it but yourself. When the season's botanizing is over with, you can enter upon the most inspiring and delightful task of starting your permanent herbarium. Special papers come for this, and they are of two kinds: one for the leaves (white or cream), and one for the covers (tan or brown). They are both after the order of parchment paper—heavy, durable, untearable, and of heavy weight. They should be of folio size; each page devoted to a specimen, unless it be too small, when several may be artistically arranged on one page. In the lower left-hand corner there should appear, neatly printed, written, or typewritten, the following data: the scientific name of the specimen according to the most recent authorities; the most widely employed popular name in brackets; the place and date of collection; the name of the collector, with a few lines on the color of the flowers and leaves; sexual characters, and the normal form and color of parts that become much distorted and changed through the process of pressing.

These folios should, as they are being completed, or even when in actual use and being continually added to, be filed in a special cabinet, with the compartments arranged according to the system you are employing in your work as to orders, genera, and so on.

My hope is that the few paragraphs I have been able to give here on this subject will induce many a boy and girl in various parts of the country to start an herbarium of the trees, shrubs, and plants of the region in which they live.

There is still another powerful adjunct to the flower-student's equipment, which must not be overlooked in this preliminary chapter on the subject; the photographic camera. Flower photography is a very expensive and often very difficult pursuit. Many things enter into it requiring special skill, long training, and experience, before one can hope to be at all successful. Some of the main things to be considered are: the selection of a complete and scientific outfit for studio and field-photography of flowers; as complete a knowledge as possible of the flowers to be photographed, and the use of a camera and its accessories in the field under all conditions, such as time, place and weather. Your artistic sense will come powerfully into play here, in the studio as well as in the field, and you will soon realise that the point of view from which a flower, a shrub, or a tree is taken makes all the difference in the world when the final result of the operation appears on paper, or is thrown upon the screen at a lecture.

*From *American Forestry*.

A Milk-Boiling Device

AMONG the various devices which are intended to prevent milk from boiling over, we noticed one which solves the problem in a very simple way, and the device is very easily made up, on the contrary to some rather complicated ones which are proposed for this purpose. It consists of a straight tube of say two or three inches diameter at the top and expanding somewhat towards the bottom, where it is provided with a flaring and cup-shaped end of rather large diameter, the whole being somewhat of trumpet shape. Out of the lower part are cut say four suitable openings, and we set the device upright in the vessel with the small end just out of the liquid. Should the milk tend to boil violently this action commences at the bottom, and the liquid is forced up the tube, then falls upon the surface again, so that the boiling action will continue in this way and the milk has no tendency to leave the vessel.

The Chronaximeter*

A New Apparatus for Electro-Diagnosis

THE study of the troubles affecting the motor nerves, whether caused by injury or by disease, depends primarily upon electro-diagnosis, that is, upon the examination of the reactions of the diseased nerve and of the muscle it governs to electric excitations. These reactions are modified with respect to those of normal nerves and muscles in the following manner:

1. The muscular contraction provoked by an excitation is slower than that of the normal muscle.

2. The muscle becomes only slightly excitable by the waves produced by the induction coil or by the discharges of condensers (faradaic excitation), while its excitability by currents from a battery (galvanic excitation) is generally not modified.

3. The electric excitation produced by two dissimilar electrodes, one of small surface placed at the plane of the point where the nerve enters the muscle (motor point of the muscle), the other covering a large area in any region whatever of the body, is normally more efficacious when the electrode situated at the motor point of the muscle is negative than when it is positive; when the nerve is injured, on the contrary, it is the positive electrode which seems to assume the preponderance (inversion of the polar law).

These signs, whose ensemble constitutes the reaction of degeneration, appear indisputably when the nerve is seriously enough affected; but this is not the case when the lesions are very slight; hence to determine whether the muscular contraction is slightly retarded, whether the positive electrode seems to act a trifle more efficaciously than normally, whether excitability with reference to induction shocks or the discharges of condensers is a little diminished, constitutes a delicate investigation resting entirely upon the skill or clinical sense of the operator, and somewhat dependent, moreover, on the instruments he employs.

It is easily understood, therefore, what a high degree of interest attaches to the discovery of a perfectly objective sign, independent of the operator and of the electric installation, and this is what has been accomplished by Professor Lapicque, of the Museum of Natural History. To thoroughly comprehend the utilization of his process, it is necessary to recall briefly the physiological data serving him as a point of departure.

Just as the muscles of different animals vary in rapidity of contraction, experiment has shown that they behave differently toward electric excitations acting upon them either directly or by means of their nerves as intermediaries.

If we act upon a muscle by battery currents of variable duration, but alway superior to a certain fixed value, we find that the intensity of the current just sufficient to provoke a contraction is identical for the diverse excitations employed; in other words, the duration of the passage of the current seems to be of no importance. However, if we employ excitations more and more brief, we perceive that below a certain period of duration it is necessary to augment the intensity in order to obtain a contraction, and to augment it more and more as the excitations become shorter and shorter; in other words, the intensity necessary just to produce a muscular shock remains constant at first while the duration of the stimulus decreases; then, starting from a certain limited duration, termed the *useful time* of the excitation, it increases more and more while the time of the passage of the current diminishes more and more.

The useful time has always the same value for a given kind of muscle; its consideration is often replaced by that of another parameter, whose definition, a little more complex than the preceding, can be summed up as follows:

If we regard closely the relation which exists between the duration t of the excitations, and the intensity i just sufficient to obtain a contraction, we find that it is

$$i = \beta\left(\frac{\tau}{t} + 1\right),$$

in which β and τ designate constants. As we see, β is the limited value of the intensity when the duration becomes infinitely great. In reality, as has been said above, this limited value is attained as soon as the duration is superior to the useful time; the formula, therefore, is only approximate. The significance of the constant τ is as follows: If we make the excitation by means of a current whose intensity is double that of the limited intensity β, the duration necessary to obtain a response from the muscle, given by the equation:

$$2\beta = \beta\left(\frac{\tau}{t} + 1\right)$$

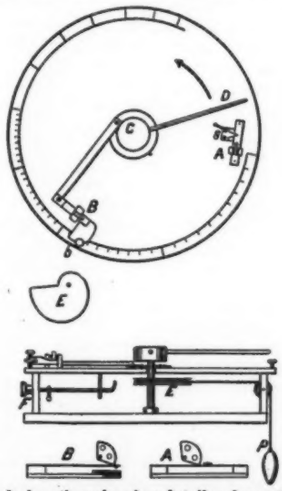
is exactly equal to τ. To this constant representing a period of time Lapicque gives the name of *chronaxia*. For a given kind of muscle the chronaxia has an invariable value, about one-tenth that of the useful time.

The two preceding characteristics (chronaxia and useful time) are perfectly independent of the conditions of the experiment, and constitute, therefore, objective and numerical data relative to the excitability.

The Chronaximeter of Prof. Lapicque

Moreover, experiment has shown that they bear a relation to the rapidity of the muscular contraction. In classifying the different muscles of various animals according to the value of their useful time (or of their chronaxia), we find that they are classified at the same time according to their rapidity of contraction—the shorter the useful time the more rapid the muscles. For example the rapid muscles of a frog's hind foot have a useful time of three one-thousandths of a second, while the slow muscles of the foot of a snail have a useful time of one-tenth of a second.

These physiologic results have an immediate application for electro-diagnosis. In the course of degeneration the useful time and the chronaxia augment in the same degree that the muscular contractions become slower; their determination indicates with precision by



Plan and elevation showing details of construction

the independent figures of the instrumental installation and of the operator, the state of the degeneration at each instant, and permits us to follow its development, step by step, as the temperature permits us to follow that of a fever. To render this method practical all that is necessary is to construct an apparatus simple, easy to handle, and not too cumbersome. Prof. Lapicque's chronaximeter fulfils these conditions. As shown in the drawings, it is composed of a circular horizontal plate, carrying on its periphery a scale at the zero of which is fixed an electric contact A. Another contact B carried by the end of a movable arm, can be set by means of the screw b at any point whatever on the scale. The plate is pierced at its center by a vertical shaft whose head is solidly united with a horizontal steel rod D. This shaft below the plate, carries a pulley E in the form of a snail, upon which, is wound a wire passing over a guide pulley and supporting a weight P. When we allow the weight P to fall freely under the gravitational pull, the resulting acceleration combines with the shape of the pulley to make the rod D turn at sufficient speed so that its extremity describes an arc one centimeter long in a thousandth of a second. In this motion the rod meets successively the contacts B and A, and in each case rocks a cam, thereby closing a circuit in B and opening it again in A. The result is that the duration of the passage of the current is equal to the time required by the rod to traverse the space BA. For a more perfect comprehension of this mechanism the reader is referred to a former article upon the measuring of brief periods of time in electro-physiology.[1] The duration in question is at once given by the number of the scale mark at which the contract B is placed. By removing or approaching the latter to A we can vary the time at will, so that it is easy to determine the useful time of the muscle under consideration by means of a series of excitations whose durations regularly increase or decrease.

For the muscles of a normal person the useful time is about three-thousandths of a second. It augments in the progress of the degeneration, and may become a hundred times as great. This fact, in connection with the other fact that the muscle loses its rapidity of contraction shows that the degenerate tissues have become slow tissues. Other things being equal, degenerate muscles bear the same relation to healthy muscles of the same kind that the muscles of the snail bear to those of the frog.

If, in the degenerations indicated, the useful time is of the degree of the tenth of a second, it is important to remark that, for the slightest nervous alterations perceptible by the ordinary methods the rate is already ten times as great as the normal. Hence its determination in this way may serve to detect slight affections in which the classic signs of the reaction of degeneration have not yet appeared. In particular, the application of this process has shown that when a muscle degenerates because of the severing of its nerve, the neighboring muscles, whose nerves have not been interfered with, present, nevertheless, a very slight degeneration, betrayed by a very slight augmentation of the useful time.

Thus, this novel technique, completing clinical observation by objective and numerical data, permits us to follow step by step the development of the degeneration. Thanks to this it is possible to determine very rapidly, by observing the variations of the useful time for a few days only, whether the effects of a lesion are growing better or worse, a valuable piece of knowledge when the advisability of surgical interference is being considered. At this special time, when nervous lesions, because of the war, form a chief concern of electrotherapeutic physicians, Prof. Lapicque's chronaximeter seems likely to render great services.

*Reprinted from *La Nature* (Paris).

[1] *La Nature*, 41st An., No. 2105, p. 290.

Preventing Dry Rot in Structural Timbers

IN the erection of buildings in which timber is used, it is a common thing to hear complaints as to "dry rot" not being sufficiently guarded against. In many cases there are structural faults which lead up to the prevalence of dry rot, some of which faults could probably be avoided, but in many cases the conditions favorable to fungoid growth cannot be got rid of, except at prohibitive cost. Ventilation can, of course, be arranged for in every case at small expense, but dampness and warmth cannot be so easily dealt with, this making the use of some fungicidal dressing desirable. In this respect, probably sulfate of copper is as good a dressing as can be used, as even a very weak solution is fatal to all the lower forms of fungoid and vegetable life, one four-millionth part of sulfate of copper in pond water keeping it clear from the lower vegetable growths, and provided the surface of structural timbers—especially the ends—is dressed with a 5 per cent solution of copper sulfate in water, all fungoid growth will be stopped and prevented. The thing is cheap enough, but a thorough and complete saturation of the surface is necessary.

—*The Practical Engineer.*

With Everyday Birds*

Some Peculiar Problems of Their Home Life

By A. A. Allen, Ph. D.

As the years go by and the number of ornithologists and people interested in birds and bird life is continually increasing, investigations are carried farther and farther afield, until the most remote and inaccessible corners of the globe are being searched for new birds and new facts about those already known. But the world is not large enough for all to be travellers and explorers and there are many who must be content to stay at home and interest themselves in the problems of everyday birds. Many questions have lain unanswered for generations, others are continually arising, so that the stay-at-home ornithologist should never be at a loss for something to do. Some of the problems bear directly on the birds' relations to man and are of great economic importance; others are valuable in our search for truth or interesting in the parallel which they make to our own lives. All of them give new zest to the study of birds and disclose how much goes unseen and how little of what we do see, we understand. They teach us to observe more carefully and to reason logically.

Perhaps no field of ornithology offers greater opportunity for discovery than that of the home life of birds, and certainly no field is more delightfully full of surprises. One has a reason to feel, for example, that everything that can be learned about robins has already been discovered and published. Here, however, is an incident which will bear further study.

A few years ago there was brought to the author a double robin's nest, but as it was not discovered until after the birds had left, nothing was known of its history. A glance at its structure, however, would convince anyone that the two compartments were built at the same time and that both had been occupied. The author was at a loss to account for it and therefore when this spring his attention was called to a similar pair of nests that were still occupied, interest was redoubled. The two nests had a common foundation over the post of a front porch and adjoined each other closely although the rims were distinct. The nests were not discovered until after both were completed and the eggs laid, so that nothing is known of how they were built. At this time, however, a bright-colored bird, presumed to be a male, was sitting on three eggs in one nest and a dull-colored bird, presumed to be a female, was incubating three in the other. As the author had to leave by an early train, further observations were made by the discoverer of the nest, Miss Mabel Carey.

The day following, another egg appeared in the "female's" nest and two days later, the eggs in the "male's" nest hatched, showing that there must have been an interval of nearly two weeks between the laying of the two sets of eggs and probably, therefore, between the building of the two nests. With the hatching of the "male's" eggs, the "female" showed considerable interest in the young birds and helped to feed them several times during the day, although she spent most of the time on her own nest. Now, however, a third robin appeared, bright in color like the first "male" and helped feed the young but did not stop to brood. Neither of the two "males" showed much interest in the "female's" nest until four days later, when "male" number one was seen to incubate the eggs for a short time when the "female" was in search of food. The second "male" continued to help feed the young and often came when both of the other birds were present, the first "male" usually leaving upon his arrival but sometimes merely backing up and permitting him to feed.

Thirteen days later all four eggs in the second nest hatched and the other young were almost ready to leave, crowding over on to the second nest until the "female" had difficulty in getting upon it to brood the newly hatched young. The next day the "male's" young flew to the ground, while the "female" continued to brood until the middle of the afternoon. She did not, however, feed them and before evening deserted them to help feed the fledglings with the result that the next day all were dead.

Now what is the explanation of the double nest? What were the relations of the three birds and why did the "female" desert her young? The greatest difficulty arises because the sexes of the different birds could not be determined accurately. The two brightly colored birds have been called "males," but it is known that mature females may be as bright as males and one or the other might have been a female. We have, therefore, two alternatives.

Assuming that both of the bright birds were males, we would have a case of polyandry, but it is difficult to understand how two males could live amicably together, or why the second male should help the first in the care of the young. It is too far removed from bird or animal nature as we know it. When polyandry does occur, there is usually no spirit of coöperation between the different males. It is much easier to think of one of the bright birds being a female and the case as one of polygamy. It is known that polygamy does occur among birds, but nevertheless, it is difficult to explain why two females should nest so close together. It is unfortunate that the birds were not observed when selecting the site, so that it might be known whether both worked together, or whether the duller, more immature bird came later and merely annexed herself. This sort of polygamy occurs with the red-winged blackbirds when the later-migrating, immature females, which have difficulty finding mates, submit to the driving of a male already mated and are content to settle somewhere within the area defended by him, usually within five or ten feet of the nest of his first mate. It might be well to explain here that mating with most birds consists of the acceptance by the female of the nesting area selected by the male and the power of the male to keep other males out of this area. It is furthermore known that most birds return each spring to their former nesting sites and that the females reaccept their former mates provided they are still able to drive off all other males. Now it is possible that both of these female robins may previously have nested for one brood or another on this porch and, coming back together this spring, may both have accepted the one male capable of driving away all others.

A reason for the desertion of her newly hatched young by the second female lies in the fact that a bird's instinct to feed and protect fledglings is much more powerful than its instinct to care for newly hatched young, a fact that bird photographers must always bear in mind, especially when working with wary, sensitive birds in which the instinct of fear is strong. Birds that are impossible subjects while incubating or brooding newly hatched young are nearly fearless as the young leave the nest. The yellow-breasted chat is a good example. It has proven a stumbling block to photographers for twenty years, because all of its instincts are subservient to that of fear or caution. It will desert its nests and even its young upon the slightest provocation, so that it is practically impossible to secure a photograph of it. When the young are leaving the nest, however, the instinct to feed and protect them reaches its highest point, nearly balancing the bird's fear, so that during the past summer it was possible, with the exercise of sufficient caution, to secure some photographs of the male bird feeding the young. In the case of the robin, then, the flight of the young from the first nest aroused in the second female the more powerful instinct and she deserted the newly hatched young to care for the fledglings, even though they were not her own.

Observation of unusual cases such as this one of the robin is often suggestive of the origin of inexplicable habits among some species of birds. For example, many members of the wren family, including both species of marsh wrens, the house wren, the winter wren and at least three species of South American wrens and probably others, build duplicate nests. These have been variously called "cock nests," "dummy nests," etc., but they have never been satisfactorily explained. The house wren, for example, fills every hole and every nesting box in the vicinity with sticks before commencing the actual nest that is to be used. The marsh wrens build six or seven nests within a short radius, only one of which is used. The winter wren does the same, although, because of the nature of its nesting site, the various nests are farther apart. In each case the nest building does not cease with the completion of the real nest but continues throughout the season and it is not uncommon to find marsh wrens still building, after the middle of August, nests which will never be used. The explanation for this curious over-development of the nest-building instinct is difficult to see but careful observation of a large number of cases may shed some light upon it. The case of a pair of house wrens which built upon my porch is particularly elucidating.

The male bird, as usual, appeared first in the spring and immediately began filling all of the nesting boxes in the vicinity with sticks. Other males that appeared were promptly driven off. After a few days a female appeared and remodelled and completed the nest which the male had started in the box on the porch, the male helping her at intervals but also continuing to carry sticks into other boxes. By the time the complement of seven eggs was completed, we discovered another pair of wrens nesting over a neighbor's door, but soon afterwards observed that the two males were never singing at the same time and began to suspect that something was wrong. At this time our male got caught in a sparrow trap and we placed an aluminum band on his leg to mark him. Identification was now comparatively simple and we easily followed the bird from one nest to the other. It was obviously a case of polygamy. An even stranger part of the story follows:

Thirteen days after the laying of the last egg, we looked into the box in the morning and found the young hatching. Two days later, when we came home at noon, we found the male bird throwing hair and feathers out of the nest and every young had disappeared. It was evident that the young had preceded the feathers and that the father of the family was on the rampage. We hastened to the neighbor's nest expecting to find another scene of devastation, but were happily disappointed. Here, too, the eggs had hatched, but the young were still unharmed. In fact, while we were still there, the male came from our nest and began singing in the nearby tree with all his previous exuberance. Nor did he disturb this nest at all, but helped to feed the young until in due time they left the nest.

But what became of our female? Four days passed before she reappeared and when she did do so, it was with a feather in her bill, and she set to work to rebuild the nest that the male had ruined. The male had continued to sing in the vicinity as though nothing had happened and when she reappeared he mated with her as before. Six more eggs were laid and these did not hatch until the young had left the other nest. This was apparently more satisfactory to the male for, although up to this time he had been assisting the other female to feed her young, he now became very attentive to our young and assisted them through to maturity. In the meantime, the other female got her young started in life, came back, renovated her nest and with the help of the male started another brood. Thus the male fathered four broods, one of which he did away with, apparently because he could not care for two broods at the same time.

How general polygamy is among wrens has not yet been recorded, for it takes unusual conditions to determine it accurately. But the fact that they are so at all suggests a good explanation for the duplicate nests. These duplicate nests are built entirely or nearly so by the male birds and very probably to attract the females as a sort of a mating performance. The fact that the males continue to build after having secured one mate, and the fact that the habit is so prevalent throughout the family suggest that polygamy was one of the fixed habits of the wren progenitors and that duplicate nest building and occasional polygamy are the vestiges of this ancient habit.

Another interesting problem that concerns the home life of birds is that of the gregarious nesters like the night herons and the bank swallows. Why this habit should have developed with certain species and not with others will always invite thought and theory. That the presence of others of the same species nesting in the near vicinity is irritating to most birds is a familiar fact. Usually one pair, when nesting, will not permit the close approach of any other bird, especially one of the same species. Social nesters, like the bank swallows, are the exception.

The rough-winged swallows are particularly solitary in their nesting habits as compared with the bank swallows. They nest in old kingfisher burrows, drain pipes or crevices in the cliffs and though two or three pairs may build in the same vicinity, they are never truly gregarious or social and resent the approach of other individuals near their nests. While working with a pair that were nesting in an old kingfisher burrow, I noticed two other swallows which were nesting at a considerable distance occasionally flying past or even hovering for a minute before the entrance to my bird's burrow. Usually they were promptly set upon and driven away. Gradually I became aware, however, that both birds of the other pair were not being treated alike. One was always, without exception, attacked by both my birds and driven away, while the other passed to and fro without molestation. When I removed the young from the nest and perched them on a wire fence to photograph them, the second pair of swallows appeared and, as usual, one of them was promptly driven away but the other was allowed to remain. In fact, this swallow caught a passing damsel fly and actually fed it to one of the young as though it were its parent. A photograph was secured

*From *American Forestry*.

showing all three birds perched on the fence with the young just after the fourth bird had been driven away.

Now how shall we interpret this strange preference which the swallows were showing for one of their kind? Are we to think that the pair of swallows had formed some sort of an attachment for the third bird like a human friendship? Was it a symptom of polygamy, or can we read in it the origin of the social instinct in other swallows by the overcoming of the natural antipathy to another bird of the same species? It is not sufficient in explaining the origin of a social instinct in birds to state that they have come together for protection or on account of restricted nesting sites because a far larger number of species suffer from these restrictions or need of protection than actually avail themselves of the opportunity of nesting together. They have first to overcome that natural antipathy toward one another, especially during the nesting season, which has been so necessary for the dispersal of the species and for maintaining a sufficient food supply. The bank swallows have overcome it entirely, whether through polygamy or what not, we do not yet know. Possibly the rough-winged swallows are coming to it. Certainly it offers a fascinating field for study and experiment to one located near a colony of social birds.

These are but a few of the numerous observations which anyone might make and which help to make the study of ornithology most fascinating. The hundreds of little points in a bird's home life, in its migrations, in its feeding habits or in its coloration that are at present without explanation will eventually yield their secret to careful observers. Which discoveries may prove of great value to mankind and which will only add to the treasury of knowledge, the discoverer may never know and the world may never recognize, but just as surely as anyone interests himself sufficiently and trains himself to observe conscientiously, just so will he learn new secrets and reveal new truths about our every-day birds.

The Classification of Helium Stars

WHILE it is now generally admitted that the spectroscopic differences between the different classes of stars are mainly due to differences of temperature, there are two widely divergent views as to the order of celestial evolution which may be inferred. In one of them, the evolution is supposed to proceed by a continuous decline of temperature from the white to the red stars; in the other, which has been consistently advocated by Sir Norman Lockyer during nearly thirty years, it is maintained that the progression is from stars at a low stage of temperature to the hottest stars, and from these to stars at a low temperature, so that a given star will have the same temperature twice in the course of its evolution. The classifications of Rutherfurd, Secchi, and Vogel, and the expansion of these into the Harvard system, may be interpreted in terms of the first hypothesis, though actually they may be regarded as merely empirical and independent of any such consideration. The classification of Lockyer, on the other hand, is essentially based upon the supposition that there must be stars which are getting hotter as well as stars which are cooling, in accordance with the theory of condensing masses of gas or swarms of meteorites.

If the spectrum of a star depended solely upon the surface temperature, there would evidently be no observational means of distinguishing between the two hypotheses. But Lockyer finds that when stars at any given stage of temperature are brought together by reference to the relative intensities of certain lines, selected according to the indications of laboratory experiments, they are divisible into two distinct groups. The spectra, therefore, seem to depend in part upon physical conditions other than those imposed by temperature alone. The difference is quite probably due to a difference in the degree of condensation, and Lockyer's interpretation assigns one of the groups to the ascending, and the other to the descending, branch of the temperature curve. The Harvard classification takes no account of these differences, and is accordingly along one line of temperature only.

The difference between the opposing views as to the order of celestial evolution is clearly of a very fundamental character, and it is important that the question should be attacked in as many ways as possible. The work of Prof. H. N. Russell ("Nature," vol. xciii., p. 283) on the absolute magnitudes of stars has already given considerable support to the main principle of Lockyer's classification, by especially emphasizing the idea that the order of celestial evolution is primarily one of increasing density, with a maximum of temperature near the middle of the sequence. As regards the helium stars, Dr. Ludendorff found in 1912 ("Nature," vol. lxxxviii., p. 424) that the radial velocities showed a very decided systematic difference for the ascending and descending stars classified by Lockyer, a difference which was not so clearly shown when the velocities were referred to the Harvard sub-classes.

Since the publication of Ludendorff's results, Lockyer has supplemented his original catalogue of 470 stars by a second catalogue of 354 stars, and a third catalogue of 287 stars, photographed and classified at the Hill Observatory, Sidmuth (*Hill Obs. Bull.*, Nos. 3 and 5). The first attempt to utilize some of the additional data which have thus become available has been made by Dr. B. P. Harassimovitch in a recent communication to the Petrograd Academy of Sciences (*Bull. Acad. Imp. Sci.*, 1916, p. 1419). In this paper the helium stars included in the first two catalogues of Lockyer are discussed in relation to the radial velocities, so far as they have been determined. For the ascending branch there are 57 such stars in the two catalogues, and for the descending branch 47 stars.

It should perhaps be recalled that the helium stars constitute type B of the Harvard classification, and are subdivided into classes B0 to B9, in accordance with variations in detail. In Lockyer's system, seven classes of helium stars are recognized, three on the ascending branch, one at the apex, and three more on the descending branch of the temperature curve, thus:

Ainitamian

Crucian, Taurian, Rigellian — Achernian, Algolian, Markabian

It was found by Campbell that after eliminating the apparent velocity due to the sun's motion, the helium stars showed a systematic positive (receding) velocity of +4·07 km., the apex of the sun's way being taken as $\alpha = 270°$, $\delta = +30°$. This systematic error, which was designated "K" by Campbell, has not yet been satisfactorily accounted for, but it is such as would arise if, in the helium stars, the lines were subject to a pressure effect which caused them to be displaced slightly to the red side of their normal positions; the effect of such a displacement would clearly be to superpose on the real radial motions a receding velocity of about 4 km. for all the stars, irrespective of their positions on the celestial sphere. The magnitude of K, and the sun's velocity, are determined on the supposition that, in the mean, the stars are at rest with respect to the stellar system.

Forming the helium stars on the ascending branch of Lockyer's series into one group, and those of the descending branch into another, Dr. Herassimovitch proceeds in the usual way to determine the sun's velocity and the K term for each group, using equations of the form

$$V_0 \cos \phi + K = V,$$

where V_0 is the velocity of the sun, ϕ the angular distance of the star from the apex of the sun's way, V the observed radial velocity reduced to the sun by correction for the earth's orbital motion, and K the residual velocity. In each group, K is thus the mean algebraic residual after eliminating the solar motion. The results are as follows:

From 57 stars on the ascending branch	K =	+ 6.32 km. ± ½1.50 km.
	V° =	−20.84 km. ± ½2.40 km.
From 47 stars on the descending branch	K =	+ 1.17 km. ± ½1.136 km.
	V° =	−20.03 km. ± ½2.29 km.

Thus, while the resulting velocity of the sun is almost the same for the two groups, the values of K are strikingly different. For the descending branch, in fact, K almost disappears, while for the ascending branch its value is considerably in excess of that found by Campbell from all the helium stars taken together. Lockyer's differentiation of the ascending and descending branches thus receives substantial corroboration.

It was already known from the work of Campbell that the groups of stars giving the largest values of K (*i. e.*, the Harvard classes B. K. and M[1]) are among the most distant, and Dr. Herassimovitch has therefore further discussed the ascending and descending groups in relation to the mean parallaxes. Applying Kapteyn's formulæ, it results that for the helium stars on the ascending branch the probable mean parallax is 0.005″ ± 0.0009″, and for the descending branch 0.012″ ± 0.0030″. By the same process, Campbell has found for the Harvard classes B0–B5 a mean parallax of 0.006″, and for the classes B8–B9 a mean parallax of 0.0129″, which are nearly identical with the values now found for the ascending and descending stars. A predominance of B0–B5 stars on the ascending branch, and of B8–B9 stars on the descending branch, would thus account for the observed difference in the mean parallaxes. But this cannot account for the whole difference, for although there are actually a greater number of B8–B9 stars on the descending than on the ascending branch of Lockyer's curve, the excess among the stars here considered is only four. It would seem, then, as in the general case, that the more distant group of helium stars gives the larger value of the K term, and it is interesting to find that Lockyer's criteria for spectroscopic classification have so successfully withstood this further test.

Dr. Herassimovitch has also investigated the ascending and descending groups in relation to the magnitudes of stars involved. Omitting those at the summit of the curve, there are 155 helium stars available for this part of the inquiry, and the figures show that the stars on the descending branch are in general fainter than those on the ascending branch. This difference cannot be explained entirely by the excess of classes B8–B9 on the descending branch, because within the limits of a given Harvard sub-group, say B3–B5, there is the same increase in the number of faint stars on the descending branch as when all the B stars are taken together. When correction is made to absolute magnitudes, by applying the mean parallaxes previously deduced, it also appears that the stars of the descending branch are in general fainter than those of the ascending branch which fall in the same Harvard sub-class, and are therefore presumably at the same stage of temperature.

Stars at the same heat level on opposite sides of the temperature curve probably have the same intrinsic brightness, and if it be assumed that the average masses are equal, it would follow that the stars on the ascending branch must in general be of greater volume and lower density than those on the descending branch. This is precisely the physical difference which is demanded by Lockyer's hypothesis, and also by that of Russell, and it may reasonably be supposed capable of explaining the spectroscopic differences which have enabled Lockyer to sort out the two classes.

The nature of the K term remains obscure. If the greater brightness of the stars of the ascending group, which gives a large value of K, could be attributed to greater mass, and not merely to greater volume, it might be possible to regard K as a function of the mass. The effect of great mass might then be to produce the pressure displacement mentioned by Campbell as a possible explanation. Or, as Dr. Herassimovitch points out, a displacement of the stellar lines to the red, such as would account for the K term, might possibly result from the gravitational field in the case of great masses, in accordance with Freundlich's deduction from the theory of relativity. There appear to be some difficulties, however, in connection with the latter hypothesis, and it may be added that the Mount Wilson observers have been unable to detect any systematic effect of this kind in the case of the sun, although the calculated effect is considerably greater than the errors of observation (Mt. Wilson Report, 1914, p. 255). On either supposition, however, it seems improbable that there would be so great a difference in masses for Lockyer's two groups of helium stars as to account for the large value of K in the ascending group and its practical disappearance in the descending group.

It at least seems clear, from the above results, that K can no longer be regarded as a constant error, having a fairly definite value for each of the Harvard classes. Prof. Perrine has also recently been led to this conclusion (*Astrophys. Journ.*, November, 1916), and is inclined to the opinion that the observed residuals represent velocity displacements. Whatever the true explanation may be, Dr. Herassimovitch's investigation emphasizes the importance of taking account of Lockyer's criteria in the classification of stars of the helium group.—A. FOWLER, in *Nature*.

[1] K is practically zero for stars of classes A, F, and G.

Corrosion Resisting Steel and Iron

FROM an abstract of a research report by D. M. Buck and J. O. Handy, prepared for the American Chemical Society, and published in the *Iron Age*, it appears that sheet iron or steel containing an addition of copper to the amount of 0.25 per cent has the property of resisting corrosion when exposed to the atmosphere to a considerable extent. Larger amounts of copper gave little or no improvement in results; and some previous work done by one of the investigators seemed to indicate that 0.15 per cent of copper is in most cases equally as efficient as the 0.25 per cent plates.

Greenbottle flies lay their eggs in large clusters upon any dead animal matter. They choose the darkest recess of the corpse, crawling in under the tongue or into a wound or even among the feathers, if the creature is a bird, in order to hide their precious eggs. Here we see a dead bird's open bill with a fly laying its eggs in the throat. The fly family, although put down as a pest, must be given credit for certain good deeds. To be sure they are dirty creatures, yet if it were not for the flies in general, carrion would be ages in disappearing where left unburied.

The Fly Menace

It would serve no useful purpose to again rehearse the long story of the menace of the fly and its obnoxious habits, for it has already been repeated so many times that every intelligent person should be thoroughly familiar with it; but the illustrations on this and the following page will serve as a reminder of its ever-present danger, and its enormous capacity of reproduction. It is difficult to drive such facts home, when people cannot see all the facts with their own eyes, and there is also an unfortunate, and slothful habit of leaving active measures of prevention to someone else; for what appears to be everybody's business is nobody's business. When an epidemic of disease arises, however, it is no respecter of persons, and all should realize that self-protection by exterminating the fly is a desirable measure—even if it does help someone else at the same time. The fly is again with us and every one destroyed, helps.

The Planetary Origin of Water*

A Theory Deduced from the Work of Many Investigators

By Dr. F. Garrigou, Adjunct Professor of Hydrology, College of Medicine and Pharmacy and Director of Institute of Hydrology, University of Toulouse

For a number of years chemists have known that water was a compound, primitively gaseous, composed of two atoms of hydrogen and one of oxygen. But whence came these atoms? What force united them? At what moment did this union take place to produce the enormous masses of liquid on the earth? These were problems for which science had no solution to offer.

The world which we inhabit forms part of an *ensemble* having the sun for the pivot about which gravitate a series of stars, and similar to thousands of analogous systems. The philosopher Kant, and the mathematician Laplace, explained the formation of these systems and their segmentation by the hypothesis of the primitive existence of a vaporous mass filling all space, which was broken into fragments and condensed, remaining thenceforth subject to invariable laws regulating the position, course, life, and future of each fragment. Let us next recall the hypothesis, equally marked by genius, of the illustrious chemist, J. B. Dumas, upon the subject of the possibility of conceiving a common origin for all metals. Dumas regarded hydrogen, one of the constituents of water, as having been the possible source of the formation by means of successive transformations of the entire series of metallic star constituents. His genius conceived this theory from conclusions furnished in his epoch, already more than half a century ago, by modern astronomical knowledge, but not yet provided with the spectroscope. This instrument confirms the ideas of Dumas as correct and as opening a pathway to new views of the true concept of matter. Hydrogen, thanks to the spectroscope, was the first gas discovered in the cosmic matter of which nebulæ and comets are composed, where it is sometimes accompanied by carbon and nitrogen.

Astronomers have enunciated the idea that these wandering stars, composed of imponderable matter, may have been born stars. Janssen has classified them into white, yellow, and red stars, the spectroscope having succeeded in so decomposing them as to indicate their chemical composition, and even the prevailing temperature of each, the number of metals varying as a direct result of this temperature. Janssen is also able to determine the relative age of each kind of star, the white stars being the youngest, the red stars the oldest, and the yellow stars intermediate.

Here follows a letter written by Janssen to Dr. Garrigou, supporting the latter's theory of the origin of water:

Meudon, June 26, 1907.

. . . "Without going into details, the stars in general are classified into three groups. To the first group belong the youngest, such as Sirius. Their light is bluish white, their spectrum characterized by the great extent, of the refrangible part of the continuous spectrum; scarcely any lines are found therein except those of hydrogen; however, some of the spectra of those stars also show the lines of metals, mainly of iron.

"The second group contains stars in a more advanced state of evolution, their color being that of our own sun, *i. e.*, yellowish; the lines of metals and metalloids are more numerous; the violet-white portion of their spectrum less pronounced; the type of those stars, *e. g.*, is Capella.

"The third group comprises stars which are approaching extinction. They are red; their spectrum is furrowed by absorption lines which form bands decreasing toward the red portion or towards the blue portion. All that concerns the problem of the presence of oxygen in the sun has been the subject of my studies since 1862. I have sufficiently demonstrated that oxygen cannot form a part of the solar atmosphere in the state which would produce in the spectrum the characteristic change. Janssen."

[The author next quotes another letter from Janssen in reference to the formation of water upon the earth and to the salinity of the seas.]

"My dear Doctor and friend:

"The phenomenon of the formation of telluric water at 1,100° C. is sufficiently well-known. I have demonstarted that the salinification of the oceans was accomplished simultaneously with the formation of water, and *not subsequently*, by the dissolution of the rocks. This results from the constitution of the chromosphere. J. Janssen."

In his communication to the Congrès 'dAlger in 1881, M. Janssen had said, before the Section of Physics: "The study of the constitution of the sun will throw light upon a throng of questions concerning our own globe," and he saw herein a new and potent motive for pursuing his studies with still greater energy. For example he cited the question of the saltness of sea-water.

"It would be very difficult," he said, "to decide with certainty whether the first sheets of water formed upon the surface of the globe were sweet or salt. But the study of the solar chromosphere leads to the conclusion that the primitive oceans must have contained the principal mineral substances which we find by their bosom today." He then developed the arguments

*An abstract from *Revue Scientifique*, Paris.

The eggs of the greenbottle are cigar-shaped, glossy white and deposited in large clusters. They hatch in a day or two giving place to very active maggots which burrow at once into the decaying flesh. By a strange process, by which they disgorge a fluid pepsin, the young flies dissolve the flesh and then drink it in the form of soup. This is necessary because the flylet possesses no chewing mouth parts whatever. If it did, living as it does among such a crowd of others, scratches would be certain to result from so many jaws and these would soon prove fatal, owing to the poisonous nature of the fluid in which the creatures live. In a week the maggots have grown tremendously. There is nothing now left of the corpse except a few bits of skin, some feathers and a few bones. The bones are mineral matter. They go back into the earth from whence they came. The other remains dry up, the odor disappears and the maggots burrow into the ground, spin cocoons and later issue into the world as flies. Thus the greenbottle rids us of many a carcass that otherwise might lay for ages putrifying in the sun. They were put in the world for that purpose, to transform the dead back into life in the form of other creatures.

upon which this conclusion was based. I had, therefore, according to the preceding statements, assembled in large part those elements which are most necessary to the discussion of the first portion of the problem in astronomical physics which I have set before myself—elements drawn from sources absolutely irrefragable from the point of view of the scientific worth of their authors. I knew that hydrogen had existed for all time (in cosmic matter). I knew, likewise (by the general hypothesis of J. B. Dumas), that it had been regarded as a gaseous metal capable of being considered as the origin of all other metals in virtue of successive transformations due to causes as yet unknown. I knew, finally, that it constituted one of the elements of water.

It remained to discover the origin of the second constitutent of water, oxygen, which sustains all life upon the earth. Oxygen fails to appear in any star which has been subjected to spectroscopic examination; hence it has been necessary to employ an indirect means for arriving at a conjecture as to the moment when it was able to achieve its appearance in nature, and to unite with hydrogen to form water in the stellar mass destined to become the earth. It is customary in chemistry to give to the metallic bodies whose rays are revealed by the spectroscope, whether in the stars or upon the globe, the name of *simple bodies*. Yet if the concept of Dumas, that these bodies are derived from hydrogen be true, then they cannot be, and are not, simple bodies. There is hydrogen, to be sure, but there are also associations wherein intervene electrons, which escape our means of investigation, since the spectroscope does not reveal them.

This is entirely admissible, since scientists claim to have decomposed into two elements bodies hitherto considered simple bodies—for example, iodine and chlorine.

Ramsay, the illustrious discoverer of argon and of helium, perceived that the emanation of radium, accepted as a simple body, decomposes into other bodies—hydrogen and helium. Debierne proved that actinium, the chemical companion of radium, also yielded hydrogen and helium upon being decomposed. And is not uranium the most beautiful example of a metal assumed to be a simple body yielding another metal—the most extraordinary of all in its properties—*i. e.*, radium, of which it is the inseparable companion? And what shall we say of copper and of lithium, the debates upon which between Ramsay and Mme. Curie are not yet closed?

Is not oxygen the same sort of binary compound as the preceding simple or assumed by simple bodies I have just named? And since it is never found in the stars, is this not due to the fact that the elements which compose it are as yet unknown, the psychological moment of their union to form water (H_2O)having not arrived, and the combination of hydrogen and oxygen to attain this result waiting upon conditions mathematically determined by nature in the astral life, and not yet fulfilled?

This supposition, however specious as it may appear at the first glimpse, rests upon no unfounded hypothesis. The English savant Soddy, the collaborator of Ramsay, some years ago read a very interesting note upon this subject before the Royal Society of London to which no objection was offered. This note tended to establish the view that oxygen is not a simple body, but is formed by the association of two distinct gases. On submitting oxygen to the silent electric discharge Soddy found that the gas collected at the cathode possesses a density perceptibly different from that of oxygen not subjected to this electric action. The density is less in the case of long sparks, and greater in the case of short sparks. It would seem, therefore, that the ordinary density of oxygen represents simply the maximum density of the molecules which compose it (8 times heavier than those of hydrogen), and that the effect of the electric discharge is to separate these molecules, while reuniting those of the same weight. Such is the reasoning of Soddy. Consequently, it would result from this research that oxygen is not a simple body, and its own proper spectrum may have escaped the astronomers, making it impossible to discern the date at which it was possible to form upon the surface of our planet. Janssen indeed opined that this water must have been produced at the same time as its saturation with chloride of sodium. At any rate, Jenssen having affirmed "that oxygen could not possibly form a part of the atmosphere of the sun (nor of the red stars)," and Trobridge as well as Hutchins (*Astroph. Journal* xxxiv, p. 345, 1887), having made the same affirmation, we must consider these opinions as demonstrated. It is, therefore, probably at the moment when the star, the future earth, was about to be extinguished and pass into the state of a planet, that oxygen must have been produced in its volatilized metallic mass still possessing a certain reddish glow.

But it was not sufficient for this gas merely to have made its appearance to enable it to unite with hydrogen and form water. It was necessary also that the temperature of this star should be sufficiently low to enable the two gases H and O to combine. We know that the combination of these two gases in the form of water cannot be maintained above 1,100° C. At this temperature the vapor of water decomposes into its two elements, H and O. Consequently the compound H_2O could not exist in the presence of volatilized metals, nor even in contact with those which, though already in the liquid state long maintain a temperature in the neighborhood of red-white. Obviously it was necessary that the temperature should fall below 1,100° C. before oxygen would unite with hydrogen.

Only the exterior surface of this immense globe of metals in a gaseous state could realize the required conditions, thanks to the low temperature of interstellar space with which it was constantly in contact. A moment arrived when the temperature of the layer of vapors immediately in contact with space fell to 1,000° C., and thenceforth the vapor of water could exist and form a minute pellicle limited exteriorly by the sphere, still on fire, but whose solid kernel was beginning to be formed by the condensation of metals liquid at 1,000° C.

Little by little, as the continuous radiation accomplished without cessation its chilling action, the external layer of water vapor, became thicker and thicker. Must it not be true that likewise the red coloration of the dying star augmented more and more? The sun looks red to us when a layer of clouds is interposed between us and its disk.

The phenomenon of the formation of water having begun, according to the theory which I have just set forth, nothing could stop it. It would inevitably continue rapidly and increasingly, for the particles of water thus formed must fall back into the mass in the form of ice due to the sudden cooling of the superior layers in contact with the celestial cold, and they would be revolatilized with like suddenness by reason of the enormous temperature of the medium into which the scraps of ice would fall. There would thus take place a coming and going movement whose force and rapidity it is difficult to conceive, but which it is allowable to consider as having been exceedingly intense.

And we may suppose that thenceforth the formation of the primitive oceans was sudden and rapid, producing uniform minerological phenomena throughout the primary terrestrial crust.

Such is the theory of the formation of water to which my deductions have led: To resume, this theory is based: 1. Upon the existence of hydrogen in all nebulæ and in all stars of whatever age. 2. On the nonexistence of the spectrum of oxygen in any star, whatever its age. 3. It rests upon the fact that the red stars are those which are approaching their extinction and their entrance into the planetary states. 4. Finally, it rests also upon the other undeniable fact that upon being extinguished these stars cannot avoid the physical effects of the glacial cold of the celestial spaces, an excessive cold which has perhaps been one of the causes of the formation of oxygen in the red star at the psychological moment.

It is now easy to comprehend, after this exposition, why I have desired to cite the divers unpublished and valuable documents which were in my possession, and which I would have made known in my first scientific publication upon this subject, in 1907, if they had not been temporarily mislaid.

I am entitled, therefore, to consider my theory of the origin of water as supported by seriously established scientific data since the anthors of these are such men as J. B. Dumas, Janssen, and Saint-Claire Deville.

But there was a gap between these three discoveries in the correct interpretation of their scientific language. It was necessary to establish a synthesis of them, as Kirchoff and Bunsen established a synthesis of the discoveries of Newton, Wollaston, and Fraunhofer, in order to construct the practical side of spectroscopy.

I have been led to establish that of the formation of water by the discoveries of my illustrious masters, and this is the sole merit which my modest intervention in the history of the *origin of water* has the right to lay claim.

Chemical Changes Produced by the Addition of Lime-Water to Milk

THE addition of lime-water to milk, which normally contains a quantity of insoluble dicalcium phosphate, results in the precipitation of more calcium phosphate, the insoluble phosphates under these conditions being a mixture of di- and tri-calcium phosphates; at the same time, the acidity of the milk is reduced. When milk to be used for feeding infants is treated with lime-water and then diluted with water to twice its original volume, or more, the soluble calcium and phosphorus may be reduced to amounts less than those present in human milk.—Note in an article by A. W. BOSWORTH and H. I. BOWDITCH in *Jour. Biol. Chem.*, from *Jour. Soc. Chem. Ind.*

Further Study of the Atomic Weight of Lead of Radioactive Origin*

By Theodore W. Richards and Charles Wadsworth, 3d
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THE recent independent and almost simultaneous investigations upon the atomic weight of lead from radioactive minerals have proved with very little room for doubt that the substance derived from this source has a much lower atomic weight than ordinary lead.[1] This conclusion is so important in its theoretical relations that its every aspect should be carefully investigated. Accordingly, the present paper represents further research in this direction, embodying determinations of the atomic weight of new samples of varied origin. The outcome entirely supports the earlier conclusion.

Four samples from widely separated sources were studied in the present research, namely, lead from Australian carnotite, from American carnotite, from Norwegian cleveite, and Norwegian bröggerite.

The first of these samples was obtained in large quantity through the kindness of Mr. S. Radcliff and Mr. E. R. Bubb, of New South Wales.

The preliminary purification of the sample was carried out in Australia.[2] Our subsequent purification was briefly described in a recent paper,[3] but some additions to the account are needed. The metallic lead was dissolved in nitric acid, leaving practically no residue. A portion of the nitrate thus obtained was precipitated with 20% hydrochloric acid from dilute solution. Lead sulphide was precipitated from the warm acidified solution of this chloride by pure hydrogen sulphide, and after separation and washing was dissolved in pure nitric acid. The small portion oxidized to sulphate during this process was boiled with sodium carbonate and the lead carbonate, washed free from sodium, was dissolved in nitric acid and united to the main portion of the nitrate, which was recrystallized four times from pure water and precipitated as chloride from a warm solution in a quartz dish with hydrogen chloride. The precipitate was centrifuged, dissolved in water and recrystallized four times, each time having added a few drops of hydrochloric acid to prevent the formation of basic salt. The second mother liquid gave no test for nitrate. This chloride formed Sample A, and after two additional recrystallizations a similar specimen constituted Sample B.

The second portion of the original nitrate made from the Australian sample was purified in a much simpler fashion. Avoiding the troublesome precipitation with hydrogen sulphide, the nitrate was recrystallized five times successively by adding concentrated nitric acid to its aqueous solution; then the lead was converted into chloride, and by precipitation with excess of hydrochloric acid this salt also was recrystallized five times. This was Sample C of the chloride, a portion of which before the last crystallization had served to prepare Sample D of the metallic isotopic lead used for determining the density.[4]

The next sample, designated F, was prepared from American carnotite and came to us in a considerably purified state through the kindness of Dr. C. H. Viol, of Pittsburgh, and of Prof. W. D. Harkins. The method of further purification was essentially like that just described.[5]

Two other samples of especial value and significance were obtained through the kindness of Dr. Ellen Gleditsch, of Kristiania. Both came from primary rocks—Norwegian pegmatite dykes. The purification of one of these, from cleveite, has already been described;[6] the source of this material, which occurred in cubic crystals and was carefully selected, was near Langesund, Norway. It was recrystallized first as nitrate and then as chloride three times, each in the usual manner, and the pure substance was designated as Sample G.

Yet another sample, designated H, was prepared from lead sulphide, also kindly sent by Dr. Gleditsch, obtained from selected crystals of Norwegian octahedral bröggerite from Roade, near Moss, Norway. This was purified in precisely the same way as lead from cleveite.

In addition to these four samples containing isotopic lead enough ordinary lead was carefully purified to serve as the basis of control analyses. The purest "test lead" of commerce, free from copper, was dissolved in nitric acid and recrystallized four times as nitrate and four times as chloride.

Throughout this work the usual care taken in atomic weight investigations was not forgotten. The nitric acid, hydrochloric acid, water and silver were all purified by methods already often described, and throughout the work on the nitrate and chloride of lead, except in the preparation of Sample A, the material was treated exclusively in vessels of platinum or quartz. All the weighings were reduced to the vacuum standard and all other precautions usual in this sort of work were carefully maintained.

The analysis was essentially similar in every way to the method described so often in Harvard contributions. The lead chloride was fused in a platinum boat in pure hydrochloric acid; this gas was displaced with nitrogen while the substance was cooling; and finally the pure dry salt in its boat was pushed into the weighing bottle, stoppered in pure dry air with the help of the familiar Harvard "bottling apparatus" and weighed at leisure. The weighed salt was placed in a large Erlenmeyer flask with glass stopper very carefully ground. Enough water was then added to form a fiftieth normal solution of the salt, and the flask and contents, with the addition of a drop of pure nitric acid to prevent the formation of basic salt, were gently warmed on an electric stove, at about 50° C., until complete solution was obtained. The boat was then removed, and the residue filtered off, both boat and residue being carefully washed and the filtrate being collected directly in the precipitating flask.

The chlorine contained in this solution was then precipitated in the usual fashion by an amount of silver calculated from preliminary trials to correspond with it as nearly as possible. Any slight deficiency or excess was corrected by adding silver nitrate or chloride, and testing in the nephelometer; and the finally corrected weight is given in the table. The precipitation was carried on in a dark room, under red light, and all the usual precautions were taken.

The first two determinations of ordinary lead were only preliminary, in order to gain practice with the method, and are not included in the table below. They yielded values for the atomic weight, respectively, 207.15 and 207.16. All the other analyses which were brought forward to conclusion are recorded in the tables, which are self-explanatory.

The results of these analyses show that the different samples containing isotopic lead all give lower values for the atomic weights than ordinary lead, but that the material from each source gives a different value precisely as had been previously found in the earlier investigations in this and other laboratories. Ordinary lead gave the maximum value (essentially equal to that found by Baxter[7]) and isotopic lead from Norwegian cleveite gave the minimum value (essentially equal to that found by Hönigschmid in bröggerite[8] 206.06).

It seems reasonable to suppose that the other samples were composed of mixtures of these two kinds of lead. The value 206.34 would be given approximately by a mixture of three parts of isotopic lead like that obtained from Norwegian cleveite with one part of ordinary lead—a reasonable supposition, since the Australian carnotite was known to have contained galena. The American carnotite, Sample F, had an atomic weight which would be given by a mixture of only one part of the pure isotope with 5 or 6 of ordinary lead,—a condition which seems to indicate the admixture of very large amounts of galena with the sample in question.

Two physical properties of the several preparations under consideration have especial interest, namely, the magnitude of the radioactivity and the nature of the spectrum. Both were studied in the present research. We confirmed the outcome of earlier work[1] that the radioactivity is not proportional to the decrease in atomic weight in samples containing isotope coming from different sources. If the radioactivity were dependent upon the presence of the isotope radium G (the supposed-end product of the decomposition, the present form of isotopic lead), the rate of fall in the gold leaf electroscope for the lead from cleveite would be the greatest, and that from the American carnotite the least; but our results were precisely the other way about. There can be little question, then, that radioactivity is not due to the isotope which gives the low atomic weight. Probably it is due to radium E, since in all of our samples the half-value of the radioactivity was obtained in about five days, the half life of radium E. The maximum value, approached asymtotically, is nearly reached in a month.

The spectrum of isotopic lead as thus far studied by Hönigschmid, by Merton and by Harkins, as well as by Baxter (who kindly photographed the ultraviolet spectrum of one of the samples of lead prepared by one of us with the help of Dr. Lembert) has always been found to be essentially like that of ordinary lead. In the present research we thought it worth while once more to test this question and especially to extend the inquiry to the visible portion of the spectrum—most of the tests in the past having been made in the ultraviolet region. We found difficulty in eliminating traces of copper, silver and calcium too small to be detected by ordinary analysis. Although these were far too diminutive to affect the atomic weight, we continued the purification, and after eight recrystallizations as nitrate and two as chloride, the product gave in every respect precisely the same spectrum as the purest ordinary lead prepared by Baxter and Grover, except for a vanishingly small trace of two of the most prominent silver lines.

The atomic weight of ordinary lead

SAMPLE	CORRECTED WEIGHT $PbCl_2$	CORRECTED WEIGHT Ag ADDED	RATIO $PbCl_2$: Ag.	ATOMIC WEIGHT Pb
3	3.72918	2.89325	1.28892	207.179
4	5.35111	4.15151	1.28896	207.188
			Average	207.183

The atomic weight of "isotopic" lead

	SAMPLE	CORRECTED WEIGHT $PbCl_2$	CORRECTED WEIGHT Ag ADDED	RATIO $PbCl_2$: Ag	ATOMIC WEIGHT Pb
1	A Carnotite, Australia	4.64010	3.61118	1.28493	206.331
2	B Carnotite, Australia	3.35517	4.16711	1.28512	206.339
3	B Carnotite, Australia	6.15608	4.79072	1.28500	206.334
4	C Carnotite, Australia	4.14770	3.22748	1.28512	206.339
				Average	206.342
5	F Carnotite, U. S. A.	5.31585	4.12670	1.28816	207.013
6	F Carnotite, U. S. A.	4.65899	3.61707	1.28806	206.994
				Average	207.004
7	H Bröggerite, Norway	4.29104	3.34187	1.28402	206.127
8	G Cleveite, Norway	3.92736	3.05913	1.28382	206.074
9	G Cleveite, Norway	4.45270	3.46818	1.28387	206.080
				Average	206.084

The photographs of the ultraviolet region in the Féry spectrometer were very kindly made by Professor Baxter. Photographs of the visible portion of the spectrum were made by us in the Gibbs Laboratory on specially prepared plates sensitive as far as wave-length 7800. All the work of loading and developing had to be done in complete darkness. To make assurance doubly sure, a further study of the visible spectrum was made, in collaboration with Mr. Norris F. Hall, with the help of the Hilger wave-length spectrometer, comparing visually in the same field of view the spectra of pure ordinary lead and the best purified specimen from Australian carnotite. Every line was scrutinized between the range 4000 and 7600, especial pains being taken in the red and yellow portions, the least satisfactory from a photographic point of view. No discernible differences between the two spectra were observed.

Because no lines were detected between wave-lengths 7800 and 2200 in any of the samples which were not due either to ordinary lead or to unimportant traces of well-known impurities, one of the alternative conclusions previously reached by Richards and Lembert is supported, namely, that this isotopic lead possesses the same spectrum as ordinary lead. The present outcome is especially interesting because the isotopic lead obtained from the preparations of Dr. Gleditsch was probably almost pure—certainly much purer than that examined in 1913.

*A paper read before the National Academy of Sciences and republished from the *Proceedings*.

[1] Richards and Lembert, *J. Amer. Chem. Soc.*, 36, 1329 (1914); Honigschmid and St. Horovitz, *Paris, C. R. Acad. Sci.*, 158, 1798 (1914); M. Curie, *Ibid.*, 158, 1676 (1914); Soddy and Hyman, *London, J. Chem. Soc.*, 105, 1402 (1914); also especially, Honigschmid, *Sitz. k. Akad Wiss Wien.* IIa (Dec., 1914).

[2] A description of the details is to be found in the paper by S. Radcliff, *J. Proc. R. Soc.*, New South Wales, 47, 145 (1913).

[3] *J. Amer. Chem. Soc.*, 38, 223; these Proceedings, 2, 505 (1916).

[4] Loc. cit. these proceedings, 2, 405 (1916.)

[5] A fuller description is given in our paper published in the December, 1916, number of *J. Amer. Chem. Soc.*

[6] Richards and Wadsworth, *J. Amer. Chem. Soc.*, 38, 1659 (1916)

[7] Baxter and Grover, *J. Amer. Chem. Soc.*, 37, 1027 (1915).

[8] Honigschmid and St. Horovitz *Sitz. k. Akad Wiss., Wien*, 123. IIa, 1 (2407) (Dec., 1914). He gives the name "Uranblei" to this form of lead. The name is appropriate if, as seems probable the substance may ultimately be traced back genetically to uranium, according to Boltwood's brilliant and well-supported hypothesis. Because the relation of this form of lead to radium is somewhat less remote than that to uranium, we used the term "radiolead" for it in a previous paper; but this term has also been applied to Radium D and is therefore, not distinctive. The time for a final nomenclature of these substances has probably not yet come, but the expression "isotopic lead," based upon Soddy's word "isotope," is certainly safe as applied to every substance fitting into this place in the Periodic System. We venture to suggest that the present isotope of lead be called "isolead," because it is now by far the best known of these isotopes. If any other permanent leads are verified, they might be called "meta" and "para." For the highly transitory isotoped these names would be inappropriate, since they do not resemble lead in one of its most characteristic properties, namely, permanence. These might be called "pseudo-leads," giving them Greek ordinal prefixes to distinguish between them. But we offer these suggestions without any desire to be insistent, and have not even adopted this nomenclature in the present paper. It may well be best to retain the present nomenclature, especially as regards the transitory isotopes.

Since the atomic weight is variable, but the spectrum and atomic volume[9] of these samples all the same, one can hardly avoid concluding that a part of the atom exercising an important effect upon the atomic weight is without influence upon the spectrum or volume. The dual nature thus postulated is, of course, in accord with the interesting hypothetical assumptions which have been advanced by various authors concerning the possible makeup of the atom; but our present research can go no further than support the idea of duality without defining exactly of what the two parts may consist.

[9]See Richards and Wadsworth, these Proceedings, 2, 505 (1916)

We are glad to acknowledge our indebtedness to the Carnegie Institution of Washington for generous support in this investigation.

Summary.—In this paper the atomic weight of four different samples of isotopic lead not hitherto tested, as well as one sample of ordinary lead (used to control the others), was determined. The results were as follows:

Ordinary lead	207.18
Isotopic lead (Carnotite, Colorado)	207.00
Isotopic lead (Carnotite, Australia)	206.34
Isotopic lead (Broggerite, Norway)	206.12
Isotopic lead (Cleveite), Norway	206.08

That the most carefully selected sample should give the lowest result is strong (although not absolutely conclusive) evidence that the higher results obtained from other samples were due merely to the accidental admixture of ordinary lead. No new lines were found either in the ultraviolet or visible spectrum of any of these samples. Each, except the ordinary lead, possesses radioactivity, but the magnitude of this radioactivity seemed to bear no relation to the lowering of the atomic weight.

Selenium and the Optophone*

More than a century ago, in 1787, Abbé Haüy showed how the blind could be enabled to read by passing their fingers over raised type. The suggestion was further developed in France, in England and New England, and in Germany, and books have been printed for years, especially in the type of Louis Braille, who died in Paris in 1852. Such books are necessarily bulky and expensive. A new instrument, the optophone of Dr. E. E. Fournier d'Albe, promises to help, and helps already, the blind to read ordinary type, without further preparation, with the aid of the sense of hearing and of the peculiar properties of the element selenium. To the theoretical chemist selenium is interesting; to the technical chemist it remains little more than a nuisance. To the physicist it has already rendered valuable service and promises well, though it must be admitted that the reputation of selenium is not untarnished. Lecturing at the Röntgen Society recently, Dr. Fournier d'Albe dealt with "Some Properties and Applications of Selenium." He practically confined himself to physical properties, and we will refer more in particular than he did to the optophone.

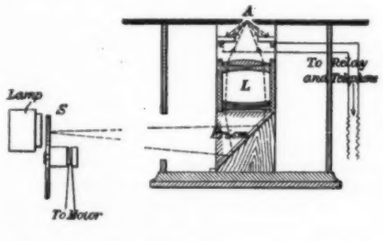
Selenium (atomic weight 79.2), the lecturer commenced, discovered by Berzelius in 1817, was one of the elements standing between metalloids and metals, being chemically intermediate between sulfur and tellurium. As sulfur ranked among the best insulators known, the late Willoughby Smith had, at the Valentia Island cable station, in 1873, tried the grey selenium modification—or melting-point 217 deg. C. and density 4.8; there are other modifications—as insulator, and he had then observed that the electric resistance of selenium varied when it was exposed to light. As the resistance was always high, special arrangements had to be made to ensure both good contact of the selenium with the electrodes and surfaces of sufficient area for exposure to light. Thus many selenium bridges (arrangements depending upon the change of resistance) or cells (arrangements in which a selenium electrode was used for generating an electromotive force) had been devised; the term cell is generally used in either case. Thin wires of copper, platinum, etc., were wound on insulators—soapstone, slate, porcelain—and coated with selenium; the cells of Shelford Bidwell and of Ruhmer, who enclosed his cell in a vacuum bulb, were of this type. Metal studs and spikes had been used. But the contact between metal and selenium led to chemical reactions—the lecturer did not go into this question, nor into the possible influences of impurities. His own cells, he stated, consisted of graphite and selenium; a thin plate of an insulator was coated with graphite, lines were scratched in the graphite, and the whole covered with selenium, which thus bridged over the gaps in the graphite. These cells were of high resistance (a cell of 5 sq. cm. surface for photophone receivers, for example, having a resistance of 100,000 ohms), and were stable for years.

When a selenium cell was illuminated the conductivity rose, rapidly at first, then slowly, and the conductivity diminished again when the light was cut off; the two curves were similar, but the complete recovery of the resistance was very slow. The theory of these changes was very complex. The selenium probably passed into a different crystalline modification, and ionisation seemed to play an important part. The behavior of selenium under Röntgen-ray bombardment supported the assumption of ionisation phenomena. Dr. Fournier d'Albe had shown, in 1913, in the Royal Society, that selenium apparatus were capable of discriminating differences and fluctuations of luminosity inappreciable by the eye.

Passing to applications, Dr. Fournier d'Albe remarked that selenium cells had first been utilized for photometric purposes, and had soon been applied by Minchin and others for star photometry, for instance, for studying the variable stars (Algol, by Stebbins). Bidwell had first rung an electric bell with the aid of a selenium relay.

*From *Engineering*.

Since 1899 Mercadier had devised various forms of multiplex telegraphs embodying selenium cells. Photo-telegraphy, attempted by Bidwell and others, had been much improved by A. Korn in 1904. In transmitting photographs by telegraphy Korn let the light beam fall through a photographic film on a selenium cell; the galvanometer needle in circuit with the arrangement varied the length of two spark gaps connected with a Tesla coil and a vacuum bulb; and luminous radiations from the latter affected a photographic film; the two films had to move in synchronism. When drawings were to be transmitted a style-electrode was moved to and fro over the pattern, the lines of which interrupted the current; the arrangements for securing synchronism between the films or electrodes or mirrors had been important factors of Korn's instruments. Light buoys had been automatically lighted and extinguished by means of selenium cells; the sunlight falling upon a cell would interrupt the relay circuit. In the demonstration of this effect the lecturer's sun was a powerful lamp, and his relay a board on which six rows of seven small selenium cells were mounted. The General Electric Company had applied similar arrangements for regulating lighting circuits. The cards for looms could be copied with the aid of selenium cells, and it had also been proposed to utilize selenium on looms in other ways. Coming to inventions in which sound and light had been combined, Dr. d'Albe mentioned Graham Bell's photophone of 1880. Bell let the beam of light fall upon the diaphragm of a telephone and concentrated the reflected waves with the aid of a parabolic mirror on to a selenium cell joined to a receiver. The singing arc could be utilized in connection with this type of instrument,



and successful wireless telephony experiments had been made near Berlin just before the war, when conversation had been carried on over distances of five miles.

The lecturer then described his optophone of 1912, an instrument devised for converting light into sound, while the photophone was to transmit sound by means of light. The principle of the optophone was that two selenium cells (or bridges) formed two arms of a Wheatone bridge, and were balanced against two adjustable carbon resistances, manganine wire serving for fine adjustment. When the galvanometer current was sent through the bridge, and the current was interrupted by clockwork about ten times per second, no sound was heard; but when one of the cells was exposed to light a sound was heard in the telephone of the galvanometer branch. The cells, a battery of 4 volts, and the clockwork had been mounted in a box, and with apparatus a blind person could discover, *e.g.*, the whereabouts of the windows and of bright objects in a room. The improved apparatus of 1913 had been devised for the reading of transparencies formed of letters about 1 inch high. The recent apparatus which was exhibited was able to deal directly with much smaller ordinary type, not transparencies, that is to say, the light did not fall through the translucent letters, but was reflected from the surface of the paper itself.

The apparatus, illustrated in the diagram annexed, consisted of a brilliant source of light, a Nernst lamp originally (now a ½-watt lamp), a siren disk S perforated with small holes arranged in eight concentric circles, and a right-angled prism and a short-focus portrait lens L. The lamp gave a line of light, intensely illuminating a vertical diameter of the siren disk; the optical arrangement threw this horizontal beam of light on to the narrow slit (about 1 mm. wide) in the flat slab or table A, upon which the print to be read was placed face downward. The paper was slowly moved on the table, so far by hand. The letter to be read at some particular moment would cover the slit and thus receive the intense illumination falling through the holes of the disk S; this light was reflected by the paper on to two selenium cells, which were mounted in parallel underneath the table, on the two sides of the slit. The cells were connected with a Brown relay and a telephone receiver; the current used (small battery) was of 1 milliampere at 60 volts. The relay, the high-resistance receiver (12,000 ohms), and the short slit (1 cm. long instead of 5 cm. as formerly) were improvements; for dealing with small type the slit length might have to be further reduced. A further great point was that the light was directly reflected from the print, which could be used as it was, while formerly transparencies had to be prepared. Delay in his researches had been caused, Dr. d'Albe explained, by pressure of other work, and in the first instance also by the impossibility of getting Nernst lamps.

The siren disk S which we mentioned was turned at 30 or 40 revolutions per second by an electric motor or by clockwork, so that the eight rings of holes gave eight musical sounds; the notes were, for instance, g, c', d', e,' g', b', c'', e''. These sounds blended together in the telephone to one musical note. When the part of the print lying over the slit A was simply white paper, this general note or tune was heard. When one letter, say l, was printed in black on a white card, and this card was slowly moved across the slit, the telephone became silent during the moment that the black l covered the slit, preventing reflection of the light. In the case of n and m two and three pauses were heard; but the sound did not completely die away, because there were the faint (oblique) strokes connecting the main (vertical) strokes of those letters. Thus not all the eight holes in a radial line would remain open, and the sound was modulated, and it was because some letters had upper appendages (h) or lower appendages (g) that several (practically at least eight) holes were needed. By means of a simple focusing device the length of the line of dots could be varied, and the instrument thus be adapted to types of various sizes. The letters w and m could be fairly well distinguished in the demonstrations; the discrimination between g, d, and z proved more difficult. All these letters were big, about 1 cm. in height, and the discrimination between smaller letters would probably require more skill. Words like "train" were also submitted for experiment; sound modulations could be perceived, but hardly anything more. The reading of ordinary type (newspaper) was not tried.

The lecturer did not say that his apparatus was actually on the market, and it might appear that reading with his optophone will be exceedingly difficult. But we must not forget that it took us months to learn to read with good eyes, and that the hearing of the blind frequently seems perfected to an astonishing degree. Dr. d'Albe said that the blind could learn to use his optophone in a few weeks. His instruments are certainly ingenious and of great promise, though there are difficulties to which he did not refer in his leacture, having dealt with them on other occasions, but which were alluded to in the discussion. We stated on our introduction that selenium has not an untarnished reputation. Everybody will remember to have heard of the fatigue of selenium. Mr. A. Campbell Swinton said he had found selenium "tricky;" the cells varied from week to week. Mr. Thorne Baker had had the same experience; an adjustment might be required from day to day, and he had recently noticed that selenium cells which had worked well at Paris would not work in London, and still less in Manchester. All the same, he had great hopes of selenium and he regretted that the experiments of Korn had not been continued. If the cells were properly constructed and well protected against atmospheric influences, they would be found reliable.

Conical ball and pebble mills grinding copper ore at the Calumet & Hecla mills

Ball Mills for Grinding Ores

THE conical mill is a device wherein the large crushing bodies arrange themselves at the largest diameter, decreasing in size toward the outlet of the cone. Coarse material entering the mill is immediately subjected to the impacts of the largest grinding bodies, is subdivided, and, according to the division, passed along to the next zone of smaller grinders, and so on until the discharge end is reached.

It will be seen from Fig. 1 that the grinding mediums automatically adjust or classify themselves to the work to be performed. An ideal stage or step reduction is thus embodied within the single machine—a combination of percussion and attrition. Comparatively a sledge hammer is used upon a spike, a nail hammer upon a nail, and a tack hammer upon a tack, utilizing all the mechanical forces with the greatest possible effect.

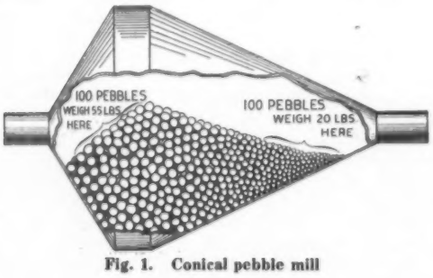


Fig. 1. Conical pebble mill

In the conical mill the material undergoing division automatically travels forward at each reduction as though actuated by an Archimedes screw, up and out the cone. Perhaps the main causes for this sizing and step reduction action can be explained by the diagram Fig. 2, in which it is shown that when the mill is operated on an inclination from the horizontal the charge is lifted at right angles to the axis, but in falling drops vertically and at an angle to the line of lift under the action of gravity. The larger particles undergoing disintegration, according to respective mass content, will fall faster than the finer particles, which must then, due to displacement, find a position nearer the outlet end of the mill. The coarse material, as well as the grinding bodies, through the acceleration due to their mass in falling, reach the lining of the mill and continue a course down the cone or inclined surface toward the larger diameter, forming a more or less of a triangular line of travel. The finer particles, according to their size, and therefore friction surface presented, are retarded in their travel down the cone by surface friction and tend to arrange themselves in zones or classified areas. It is to this zigzag action within the mill that the discharge of material as crushed becomes more or less positive and automatic, in contradistinction to the action within the cylindrical mill mentioned below.

In the old style of cylindrical mill illustrated in Fig. 3 no sizing action takes place among the several tons of pebbles indiscriminately distributed throughout its length. Although a large portion of the material fed to such a mill is sufficiently crushed within the first 2 or 3 feet, it cannot be discharged until it has slowly worked its way through 20 or more feet of partially ground material and pebbles of all sizes, interfering with the action of the pebbles by forming a cushion which absorbs power. In this old style of pebble mill the ground material is only discharged when displaced by the incoming feed, such discharge being haphazard.

The new ball mill drum consists of two cones joined base to base with a short cylindrical wrapper piece, all made up in heavy steel plate, carefully rolled, flanged, butt-strapped and riveted. The two large end trunnion castings are bored out on inside faces before being applied and riveted to the cones. When completely assembled and riveted, the drum is swung in a lathe, centered, the trunnions turned and polished, and the arms to carry the gear machined. With this method of construction and the care exercised in the steel plate work, an absolutely true alinement of trunnions is insured, with the consequent advantage of smooth running gears and minimum power consumption.

These types of conical ball and pebble mills can be used to do the work of any combination of stamp mills, rolls, or other kinds of mills to reduce the different ores to the conditions required by numerous metallurgical processes. They have the advantage of being adjustable for sliming with a minimum of coarse, or granulating with a minimum of slimes. On account of their peculiar shape, they have a positive discharge, requiring no screens. The ores and other materials being successfully reduced include gold, and silver ores, copper and lead-zinc ores also iron ores as well as phosphate rock, cement (clinker) limestone, feldspar and talc.

Fig. 3. Cylindrical pebble mill

Whale and Seal Meat for Human Food

NOT only is the ocean a vast storehouse of food in the form of fish and crustaceans, but it holds vast numbers of warm-blooded animals, and an organized effort has recently been made by the Norwegian Food Commission to exploit the flesh of these mammals as substitutes for the beef, mutton, and pork whose prices soar steadily while war continues.

Both whale meat and seal meat, it is reported, are now offered, according to *La Nature*, in the markets of Norway, particularly the latter. In 1916 no less than 64,000 carcasses of seals were brought in by the hunters. The Provisions Commission sells seal meat wholesale

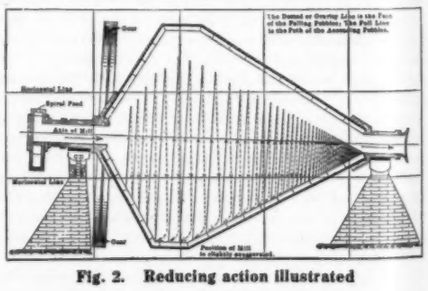


Fig. 2. Reducing action illustrated

at 0.42 francs per kilogram, about 4 cents per pound. The Commission also employs professional dieticians and cooks to give lectures, accompanied by practical demonstrations, on the value of such meat and the most appetizing way of preparing it. At Drammen, one of the chief cities in the southern part of Norway, more than 500 people attended such a lecture and retired smacking their lips over the delicacies they had enjoyed. Here are two of the recipes given:

To remove the oily flavor, the seal meat must be soaked for two days in vinegar and water, and a third day in pure water. To make *rissoles* take 200 grams of seal meat and an equal amount of beef, chop together, roll in pastry and fry in fat or margerine. Excellent croquettes are prepared thus: Take 200 grams of brown beans, cooked beforehand, 200 grams of seal meat, 100 grams of lard. Chop together and add one egg, a deciliter of milk, a teaspoonful of potato flour, and a little pepper. Cook in fat or margerine and serve.

The Influence of Speed on Endurance Tests*

In the Cyclic Application of Stress on Iron and Steel

By W. C. Popplewell

THE question has often arisen, and been many times discussed, whether in experiments on iron and steel subjected to a cyclic application of stress, the speed at which the reversals take place has any appreciable effect on the results, that is to say, on the number of cycles which are needed to cause fracture of the material, and, further, whether higher speeds or lower speeds are more favorable to increased endurance.

The evidence for and against the importance of the speed effect is of two kinds, namely, (*a*) considerations arising out of what is known to happen to a steel bar as it is being subjected to a series of very slow reversals of stress, and (*b*) the information which is derived from the results of actual tests carried to destruction.

(*a*) *Very Slow Reversals of Stress.*—The complete cycle of stress and strain which occurs in material subject to very slow reversals of stress is somewhat as follows: The cycle begins with a gradually increasing tensile stress, starting from zero, and reaching a certain maximum value; then comes a gradual reduction of stress until zero is again reached; this is followed by a gradual increase of stress, now compressive, from zero to a maximum equal in value to the previous one, and finishing with a gradual reduction of stress until zero is again reached. In this cycle the changes in stress are all very slow. The strains are partly elastic and partly semi-plastic. What actually occurs is best shown on the diagram—Fig. 1 (*a*). Here stresses are measured vertically from the horizontal line, tension upwards and compression downwards; strains are plotted horizontally from a vertical taken through the point A. The result of the plotting of the strains is a closed figure, well known as the hysteresis loop. This will now be traced out in detail.

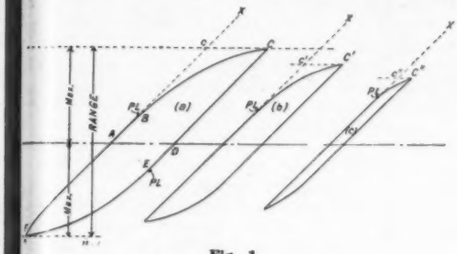


Fig. 1

At the initial point A the specimen is supposed to be in a state of ease, and it is here that the imposition of tensile stress begins. Elastic stretch accompanies the increase of stress, and the diagram follows a straight line to a point B. This is the limit of proportionality (P L), beyond which the strain is increasingly non-elastic. The stress-strain line leaves the straight and gradually curves away to C, which is the maximum point for stress and strain. The horizontal distance C *c* from C to the elastic line represents the non-elastic strain. As the stress is now decreased beyond C, the line follows the course C to D, which represents elastic conditions and is sensibly parallel to A B. This completes one-half the cycle. The other half is shown by D E F A, which is a repetition below the line of A B C D, the strains now being shortenings instead of stretchings. This is the foundation of the hysteresis loop as it would actually be formed at slow speeds.

Of the three loops on Fig. 1—(*a*), (*b*), and (*c*)—the differences in size are caused by the differences in the maximum stresses attained, these being shown by the decreasing height of C, C′, and C″ above the horizontal line. It will be seen that as these maximums decrease the proportional limits become correspondingly higher.

The author of these notes, when working to find the extent to which the natural limit is dependent on the value of the imposed maximum stress, obtained hysteresis loops similar to those in Fig. 1. The bar under test was loaded in an ordinary Buckton testing machine, first in tension, then in compression, extensometer readings being taken at uniform intervals in the loading. From a record of these the hysteresis loop was plotted. Each experiment was made just after the specimen had been subjected to a series of ten reversals to the given maximum stress, this being considered a sufficiently large number with which to establish artificial limits, equal in tension and compression. After each set another was carried out at a maximum stress somewhat higher than the previous one. By plotting the artificial limits thus found, and drawing a smooth average curve, it was possible to arrive at a natural elastic limit for the material in question. Double this limit was taken as the probable limiting range, and this value could be compared with the range as found by the more direct methods.

By way of explanation it should be pointed out here that when a steel bar is loaded in tension to a point somewhat beyond its limit of proportionality, and then reloaded in compression, it is found that the limit in compression is lower than the previous one in tension. Probably the primitive limit in compression would have been the same as the primitive limit in tension, but the compression limit in this case has been lowered by the fact of having been loaded beyond its limit under the opposite kind of stress. If now the bar be continuously reloaded to the same maximum in each case, the stress being alternately in tension and in compression, an up-and-down movement of the limit will take place, until after six or seven reversals, the limits will be found to have settled down to equal values in tension and in compression. The points where the limits have settled after the series of stress reversals may be called the artificial limits for the existing conditions of loading. These are mentioned above. From these to find the absolute natural limit—that is to say, the stress below which there can be no observed limit—the writer plotted a curve with maximum imposed stresses plotted vertically, and the corresponding artificial limits horizontally; where the smooth curve through these points cuts a line drawn at 45 degrees to the axes gave the ultimate natural limit. The writer has suggested that the natural limit found in this way is the probable value of the limiting stress for an unlimited number of direct reversals of stress. The curve on Fig. 1 is from observations taken when finding one of the artificial limits following the application of ten reversals of stress. The point where the straight elastic line is tangential to the curve is taken as the proportional limit. In these experiments it was noticed that the higher the maximum stresses imposed the lower were the artificial limits. So much for the hysteresis loops obtained under very slow reversals of stress. In these the portions A B and C D are sensibly straight and parallel to one another.

In order to find out if at these slow speeds of reversal there could be detected any difference in the position of the natural limit when the speed of reversal was varied, the writer carried out a number of experiments. Two speeds were employed, one having an interval between cycles of 24 hours, as slow a speed as any likely to be met with, and the other a period of five minutes; this being the quickest possible under the circumstances where loads had to be applied, extensometer readings taken, and the load reversed from tension to compression. No difference was observed in the position of the natural limits at these two speeds. The method here employed for finding the limiting stresses is an indirect one, but the writer thinks the results sufficiently definite to warrant the conclusion that at these very slow speeds the limiting stress is not in any way affected by considerations of speed.

Limiting stresses and ranges found by this indirect method have been compared with the results of endurance experiments under direct stress, carried out on specimens of the same material, with very fair agreement. Comparing the results of the indirect method with endurance tests on rotating beams of the same material, it was found that the latter gave higher limiting stresses than the former, and that these depended largely on the precise shape of the circular beam under stress. Both these results are in accordance with those of other experimenters.

EFFECT OF TIME

The next point to consider is that of the effect of time on the precise shape of the hysteresis loop. On Fig. 2 will be seen three of these loops—(*a*), (*b*), and (*c*). These are all taken from bars subjected to direct stresses under conditions in all respects similar, except in that of speed, and all maximums are alike. Of the three curves given, (*a*) is the form one would expect when the loading was extremely slow, say, ten cycle per minute; (*b*) is for a somewhat more rapid reversal, say, more like a normal speed met with in machinery, such as 100 reversals in one minute, then (*c*) is the kind of diagram to be expected from a still higher speed, say, 1,000 in the minute. The differences caused by the influence of time are very marked. First, comparing (*a*) and (*b*). In (*a*) from A the line curves off gradually to C, the change from straight to curve being very gradual; from C back to D there is again an almost straight elastic line, which is continued on the other side of the zero line towards F, and the loop is finally closed by the line back to A. This represents the hysteresis loop which would be drawn in the case of a bar subjected to complete reversals of direct stress and strain, where the maximum stresses are equal and the speed of reversal is slow. The chief differences between this curve and 1 (*a*) are due to the increase of the speed from extreme slowness to a speed comparable with conditions obtaining in practical work. It will be seen that the portion of the loop between A and C is curved throughout, the straight elastic portion at the beginning being merged in what was the curved part beyond the P limit, the definite point where the change occurs at B disappearing altogether. The line C D is nearly straight, coming back to zero stress at the point D, which is further away from A than it would be in the case of extreme slowness, as in Fig. 1 (*a*). The meaning of this is that when the point D is reached recovery after the strain up to C is not complete, and there is still left some permanent disturbance of the material.

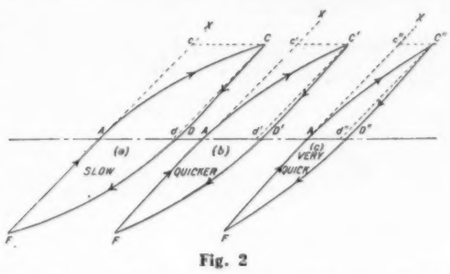


Fig. 2

When the speed is increased from "slow"—Fig. 2 (*a*)—to "quicker"—Fig. 2(*b*)—and thence to "very quick"—Fig. 2 (*c*)—similar modifications of shape follow. C *c* becomes successively smaller, and D gets further away from where it would be for slower reversals. In other words, the total strain or disturbance of the material during A C gets less as the speed increases and the residuary strain after C gets greater. The result of all this is that for high speeds C′ *c*′ is less than C *c*—that is, the disturbance of the material is less—and D′ *d*′ is greater than D *d*—that is, the disturbance caused in the material during imposition of the stress has not disappeared as far as it would have done if the speed had been slower. But the net effect of disturbance is less at the high than the slow speed. Of the positive non-elastic disturbance only part is recovered. At high speeds the algebraic sum of disturbance and recovery will be less than at low speeds. It is very probable that the greater the permanent disturbance of the material at the end of a cycle repeated many times, the earlier may the specimen be likely to break. Further, as the greater disturbance occurs when the reversals are slower it follows that the endurance should be greater when the speed is higher.

The writer knows of no experiments which have been carried out to find a definite relation between the increase of non-elastic strain just beyond the P limit and the time. But it is probable that when an increment of stress is applied—between A and C, Fig. 1—the elastic strain and the greater part of the plastic portion take place at first very rapidly and then more slowly. When carrying out the slow reversals in a testing machine, already mentioned, the writer was able to observe through the microscope of the extensometer the very things happening which have just been described as probable. It was noticed that at the very beginning of an increment of stress the observation line began to move very rapidly towards its new position on the scale corresponding to the new stress, but travelled more slowly as the bar took up its load. Where the stresses were such as to give relatively large strains it was seen that the line, when in the region C of the cycle, moved very slowly towards the end before it came to rest. Of course, these observations were of a general nature, and no measurements of speed were attempted. It should not be impossible to arrange apparatus which would give the time and strain relation, on a revolving drum. The writer thinks that all the observed facts which have been given may be adduced as arguments in favor of the theory that the endurance of steel is greater when the speeds of reversal are high than when they are low, that is, it will require greater stress to cause fracture at the higher speeds. Arguments such as these are indirect, and are based largely on what happens at very slow speeds and on the form the diagram

*The Engineer.

takes at higher speeds. It is evident that there must be a certain speed below which the speed variation can have no appreciable effect on the ultimate endurance and beyond which the endurance should begin to improve with the speed.

OPINIONS BASED ON RESULTS OF ENDURANCE TESTS TO DESTRUCTION

A list of the principal endurance tests which have been carried out is given in the accompanying table. The greater part of this list is taken from the paper in which the University College experiments are described. In the valuable discussion following this paper some interesting points were raised, and the question of speed was referred to by several speakers.

Experimenter.	Nature of experiment.	Materials.	Number of cycles per minute.
Wöhler (1)	Revolving cantilever	Phœnix iron... ...	60—80
		Homogeneous iron	60—80
		Vickers' axle steel	60—80
		Firth's tool steel...	60—80
Baker... ...	,,	Soft steel	50—60
		Fine drift steel ...	50—60
Rogers ...	,,	0·32 p.c. C. steel...	400
		Same (annealed) ...	400
Stanton and Bairstow (2)	Direct tension and compression (Reciprocating weight)	Wrought iron ...	800
		Piston-rod steel	800
Reynolds and Smith(3)	Direct tension and compression (Reciprocating weight)	Mild steel ... ... (annealed)	1337—1917 (20·9) (12·4)
		Cast steel ... ... (annealed)	1320—1990 (20·1) (13·1)
University College (4) (Eden, Rose and Cunningham)	Rotating beam	Drawn W.I.... ...	250
		,, ...	620
		,, ...	1300
		Drawn mild steel...	250
		,, ...	620
		,, ...	1300
Hopkinson(5)	Electric resonance	Mild steel	Up to 7000
The writer(3)	Slow rotating beam testing machine Direct stress	Mild steel	One cycle in 24 hours to 350 per minute
		Carbon tool steel...	

In the figures given in the above list it is to be observed that the only results in which there is lower endurance with higher speed are those of Professor Osborne Reynolds and Dr. Smith. The figures quoted above contain one pair of results for mild steel, in which it will be seen that the endurance is reduced from 20.09 tons per square inch to 12.4 as speed is increased from 1337 to 1917 reversals per minute, and there are somewhat similar figures for cast steel. These are typical of many others in the same paper, all of which show the better results for the slower speeds. On the other hand, the results of the University College experiments show an absence of any speed effect between 250 and 1,300 alternations per minute. In the experiments of Dr. Stanton and Mr. Bairstow it was found that there was considerable variation of speed in certain cases, but this did not appear to have any material effect on the endurance.

In some experiments made at the National Physical Laboratory about 1908, Dr. Stanton used test pieces in the form of rings, which gave a combination of alternating stress with rolling abrasion, and when using speeds varying from 100 to 2,200 reversals per minute he found no evidence of a reduction of endurance due to the effect of speed variation. The question of the speed effect has been investigated, further, by Professor Bertram Hopkinson, using a machine designed by him, in which the specimen supports a load which is reduced to a state of vibration by means of an alternating current and magnet. The whole system can be adjusted until the load has assumed a definite number of vibrations per minute, in this way alternately extending and compressing the specimen. Professor Hopkinson has been able to obtain as many as 7,000 reversals per minute. He found that at this speed the resistance was much higher than at the lower speeds. In the discussion mentioned he stated that he considered that the University College results conclusively proved that up to 1,300 reversals a minute the speed did not make much difference to the ultimate endurance. Another case mentioned by Professor Hopkinson in support of his opinion, that higher speeds lead to greater endurance, was the following: Using a 0.18 per cent C. steel and a machine which gave over 7,000 cycles of stress per minute, he found that the specimen could be relied upon to remain unbroken after 10,000,000 applications of the cycle of stress, the range of stress covered being 28 tons per square inch. Dr. Stanton made some tests in the National Physical Laboratory machine on this same material. He found that with his machine running at 1,000 cycles per minute, and working over the same range of stress, the specimen broke on the average after 100,000 cycles. Another piece of evidence is due to Dr. Stanton, who, in the National Physical Laboratory report for 1910, states that tests made on a rotating cantilever machine at speeds of 100, 200, and 2,200 reversals per minute showed no evidence of speed effect. It may be noted here that in the Stanton reciprocating weight machine the ratio $\frac{\text{tension}}{\text{compression}}$ is 1.4; the same ratio for the Reynolds-Smith machine is 1.15. The former of these machines is of the horizontal type.

SUMMARY

From a detailed examination of the hysteresis loop given during a complete cycle of stress it seems to be clear that higher speeds result in a smaller amount of positive disturbance of the material than do lower speeds. Higher speeds result in greater residuary strain than do low speeds. But as this negative strain is altogether smaller than the positive strain the net result is smaller for the higher speeds. This is shown by the diminishing total width A D of the higher speed loops. It is reasonable to suppose that the smaller the extent to which the material has been disturbed permanently the greater will be the number of cycles which it will endure before fracture. Therefore, as high speeds mean less disturbance, they should also result in greater endurance. The balance of evidence by experimenters on endurance tests to destruction is in agreement with the theoretical reasons just given. Eden, Rose and Cunningham, Stanton and Bairstow, Hopkinson, and the writer give results to show that high speed leads to high endurance. Against this are the very definite and remarkably uniform results of Reynolds and Smith. In the last the machine used was of the reciprocating weight type, and the first of its kind. It has been suggested that defects in the balance of the machine might account for the difference by imposing stresses at the higher speeds, which were not given in the calculations, or that the very high temperatures reached at the higher speeds might have assisted in causing the earlier fractures. Both contentions are reasonable. It is known that with the reciprocating machine of Stanton and Bairstow considerable trouble was experienced in its earlier days, and it was not until it had been taken to pieces and thoroughly overhauled that reasonably consistent results were possible.

Whatever be the truth about this speed effect, the subject is of the utmost importance to designers, and is full of deep interest It should not be impossible to carry out experiments designed solely for this purpose, in which every other influence than that of speed was eliminated as far as possible. It is to be hoped that this will be done, so as to settle the point one way or the other. The writer cannot help thinking that the available evidence is in favor of high endurance with high speed, but there are, no doubt, many engineers who think otherwise.

Papers referred to above: (1) "Testing of Materials." Unwin. (2) "Resistance of Iron and Steel to Reversals of Direct Stress." Stanton and Bairstow. "Proc." Inst. C.E., 1906, vol. clxvi (3) "On a Throw Testing Machine for Reversals of Mean Stress." Professor Osborne Reynolds and J. H. Smith. "Phil. Trans.,' Royal Society, 1902. (4) "Endurance of Metals." E. M. Eden, W. N. Rose, and F. L. Cunningham. "Min. Proc.," Inst. M.E., 1911. (5) "Slow Reversals of Stress and the Ultimate Endurance of Steel." W. C. Popplewell. "Min. Proc.," Inst. C.E., 1914. (6) Royal Soc. "Proceedings" A, vol. lxxxvi. Professor Bertram Hopkinson. (7) Royal Society, T. Phil. Trans.," vol. ccx. Mr. L. Bairstow.

White Fakirs

THE Indian fakir seated by the roadside, lost in visions of *nirvana* or some equally impossible superstition, living upon the admiring charity of ignorant peasants, too lofty to work or to talk or even to kill the flies that sting him, and clothed in rags; has his counterpart in Europe, and especially here, in the transcendental persons who would teach us that what is useful is useless and what is obvious is untrue. But the white fakirs, though they still keep the admiration of the unwise, do by no means hold the beggar's bowl, but often sit in the seats of the academically mighty and flood the world with golden words—which float away from their lips into the air as beautiful but as empty as soap-bubbles. Whatever is suggested for the betterment of things—science and modern languages in education, payment of research, experimental pathology, town-planning, sanitation—they lift their voices and cry, "Think not of this barren world; fix your minds upon the absolute. What does anything matter here? but there, in *nirvana*, eternal bliss awaits you." And loud applause greets the lofty pose. Thus when an extensive sanitary campaign was once proposed to the governor of a certain colony, he, who was suffering from fever at the time, replied sadly but bravely, "After all, what does it matter? We are here to suffer because of our duty; let us ignore our suffering, and consider only our duty." And his poor people continued to die of the disease in hundreds. Later, in another capacity, he did perhaps more harm to his country during the war than most men who are not politicians.

The opposition to more science and modern languages in education is principally due to this spirit of fakirism. Children will be debased by being taught useful things: fix not their eyes upon what is of earth earthy; give them character rather than knowledge, direction rather than force, good intentions rather than capacity; so shall they win to Heaven. We see much of this caste of thought everywhere in this country, and may mention as an example a brief report in the *British Medical Journal* of a paper read at the Royal Society of Arts on December 20th last. After pointing out, fairly correctly, that the true division of education was, not into ancient and modern, but into literary and scientific (though even this is probably not quite accurate), and admitting that the ideal was a combination of literary and scientific education, the speaker, added that "There was too great a disposition to think that knowledge in itself was valuable. It was valuable precisely in so far as it inspired and animated and trained the mind. The mere knowledge of facts was unimportant. . . . A thing which was practically useful had not necessarily any educational value." And the chairman of the meeting summed up by saying that "The great aim of education was to stimulate curiosity and to create the habit of observation. It was not knowledge that was important but the love of knowledge."

From this we gather that the effort is everything but the result nothing. So also we may say, it is not food which is important but the love of food; and our great aim should be to stimulate the flow of saliva by the exhibition of dishes which, like those put before Sancho Panza, are not to be eaten. Thus, ultimately, we shall reach the *nirvana* of absolute ignorance (and starvation) where we shall remain forever seated in the beatific contemplation of our own virtue (and hunger).

A false philosophy, this modern English one of fakirism—as false as the opposite German one of thuggism. Neither for fakirs nor for thugs has the world any use. Both are only morbidities—the fakir the worse because of his decadence.

The world requires people who do things—not those who can do things if they wish but do not do them. Such are only wastrels; and the complaint against our education is that it breeds too many wastrels. For centuries instruction has been given in the schools because the instructed person is useful to his fellows, while the uninstructed person is fit only for unskiled manual work; and the experience of centuries is apt to teach something of truth. It is idle to talk of the love of knowledge being something apart from knowledge—one might as well admire the love of swimming in one who cannot swim. *Per contra*, the world judges rightly that one who cannot swim is too lazy to learn and that one who knows nothing is a loafer. To tell the young that they should seek knowledge but that knowledge when found is of little account, is a paradox which they will detect at once but employ as an excuse for idleness; yet from every side comes the complaint that this is the doctrine actually taught in many of our schools. Science is a bore, literature ridiculous, languages too much trouble; the only things that matter are games and the cut of one's collars. This kind of spirit will serve no longer. It breeds only intuitive philosophers, conscientious objectors, anti-vivisectionists, party politicians and other charlatans; and a nation which accepts it too frequently will itself become a fakir sitting begging by the roadside of progress.

Fakirism is the degeneration of minds which possess intellectual tendencies but not the vigor required to digest the wholesome food of facts which alone can raise intellectual tendencies to the difficult summit of achievement. It is a paralysis which often overtakes fine but delicate souls, as heart-failure often overtakes athletes. We shall always find it easier to give up the ascent, to sit down, sigh and complain that the peak is not worth the pains. But success is the only sound proof of capacity; and the caste-mark on the brow of the fakir is—failure.—SIR ALFRED KEOGH, in *Science Progress*.

Substitute for Jute

ACCORDING to a recent report, a large stock company is being organized known as "Russian Jute" company, and its object is to erect a factory of considerable size at Iekaterinoda for treating a textile plant known as "kenafé," which is said to possess the properties of the jute plant. This plant is very abundant in Russia, and has been utilized for a long time past by the peasants for making twine for binding sheaves, but this is the first attempt to make use of the plant on an industrial scale. It is claimed that the fiber will answer very well for making bags, packing cloth, cord or twine, and all the well-known products which are made up from jute. The enterprise is being mainly promoted by leading jute and flax interests at Petrograd and Moscow.

Polarized Light in Vegetable Histology*

Some Investigations of Plant Tissues

By C. W. Ballard, American Pharmaceutical Association

MANY of our standard references on vegetable histology, while making mention of the polarizing apparatus, do not give much space to the effects of polarized light upon the different plant tissues. Illustrations of starch grains and crystals viewed under this form of illumination are to be found in many of these works, but further details are lacking. As the effects of polarized light are so minutely described in texts upon the microscopy of minerals and microchemical analysis, it has occurred to the writer to consider very briefly the appearances of some plant tissues and their contents when observed through the polarizing microscope.

There are several types of polarizing apparatus supplied by microscope manufacturers. The apparatus is generally separable from the microscope unless the instrument is designed for petrographic work exclusively, in which case the polarizing is built in the body tube. Of separable polarizers, the type which has a fixed analyzing prism and a revolving polarizer adjusted above the ocular is preferred to that in which the polarizer is inserted above the objective. The latter form can only be used on instruments having a revolving stage and, unless used with special objective clamps, hinders free changing from one power to another. While a graduated revolving stage is necessary in critical operations, it is not indispensable in the average work of the vegetable histologist. The most satisfactory objective for use in this work is the 8 mm. (No. 3), although the 5 mm. (No. 4) may be used. Higher powers than the 5 mm. do not give satisfactory results, as the field, with crossed prisms, is too dark to note details. It is better to use a comparatively low objective with a high ocular. The combination used in this work was 5 mm. (No. 4) objective with 10 x (No. 5) ocular. Polarization work may be performed by artificial light if a ground glass screen is placed between the source of light and the mirror of the microscope. Best results are obtained with a 100-watt concentrated tungsten filament lamp, hooded so as to shield the stage and the eyes of the observer.

From the standpoint of polarization, vegetable tissues and cell contents are divided into (a) those which have no effect upon the light rays reflected through the apparatus, and (b) those which modify the direction or speed of vibration of these rays. Materials in subdivision (a) are termed isotropic; those in subdivision (b) anisotropic. Among the points of interest or of direct value in the examination of vegetable substances by polarized light, the three here stated are perhaps the most essential:

1. Partial or total extinction, or disappearance of the object when prisms are rotated.
2. Markings observed upon rotation of the prisms.
3. Coloration (pleochroism) upon rotation, in some cases running through the shades of the spectrum.

Partial or total extinction may be due to the thickness of the object, as it has been observed that fiber-masses, which ordinarily would not extinguish, are invisible under crossed prisms if the mass is thick or the light weak. Among the tissues which undergo partial or total extinction are cork, epidermis, aleurone, resins and volatile oils. The markings observed under crossed prisms in different cellular elements or cell contents are in some instances very characteristic and may well be considered diagnostic. Starch grains, mucilage deposits and crystals are among the elements which exhibit characteristic markings upon rotation of the prisms. Many substances and cellular elements show wonderful color changes during rotation. We may classify fibers by their response to this test. The true isotropic crystals, or those classified as isometric, should not show coloration. Crystals of all classes, with the exception of the isometric, will exhibit a color change during rotation of the prisms.

PLANT TISSUES UNDER POLARIZED LIGHT

Cork.—The masses of cork tissue in the powders examined were in most instances too thick for positive determination. In sections with corky layer attached, the only change under crossed prisms was a clearer differentiation of the individual cell walls.

Specimens examined: Powdered cascara, xanthoxylum and quebracho; sections of cascara, xanthoxylum and oak.

Root epidermis.—No change could be observed in either powdered specimens or sections. Tissue totally extinguishes under crossed prisms.

Specimens examined: Powdered sarsaparilla, belladonna and calumba; sections of sarsaparilla, belladonna and calumba.

Collenchyma.—This element is usually difficult of differentiation because of the small intercellular spaces. Under polarized light the cell-walls and limits are clearly defined.

Specimens examined: Sections of peppermint stem.

Conducting tissues (vessels, tracheids and medullary rays).—The only result observed in the conducting tissues when viewed by polarized light is a general clearing of the structural details. Such tissues show no signs of extinguishing. The crossed prisms, by diminishing the light ordinarily appearing through the porous parts of the vessel, serve to clearly define the pores, both border and central, with any markings present.

Specimens examined: Powdered sarsaparilla, belladonna, hydrastis, squill, spigelia and quassia; sections of sarsaparilla, quassia and pumpkin stem.

Trichomes (plant hairs).—Details of structure are cleared, as are junction points in multicellular and multiseriate types. Extinction as well as coloration characterizes some trichomes.

Specimens examined: Powdered digitalis, lobelia, peppermint, cannabis, senna, mullein, eupatorium and salvia.

Fibrous tissues.—Aside from clearing details of structure, the most practical use of polarized light in dealing with fibers, depends upon the phenomenon of pleochroism. We may separate the fibrous tissues into pleochroic and non-pleochroic classes. Cinchona fibers exhibit this property to the greatest extent, giving many beautiful shades of color. Cinnamon fibers exhibit but slight color change under crossed prisms, while fibers of cotton root bark show no trace of coloration under this manipulation. None of the fibers examined showed complete extinction. The crystal-bearing fibers are seldom pleochroic, although the crystals contained may exhibit coloration. Polarization serves admirably to clear questions of presence or absence of crystal-sacs and defines accurately the outlines of the crystals.

Specimens examined: Powdered cinchona, cinnamon, cotton bark, quassia, sandalwood, scoparius, licorice, cascara, frangula, quebracho; sections of cinchona, cinnamon, quassia, licorice, cascara, frangula.

Stone cells.—Some types exhibit a slight but definite coloration, but the majority of specimens examined were lacking in this quality. Accurate definition of pores and striations may be secured. Thick masses, as those occurring in cubeb, are apt to extinguish.

Specimens examined: Powdered ruellia, cinnamon, cascara, aconite, cubebs, physostigma, pimenta, chionanthus, and oak.

CELL CONTENTS UNDER POLARIZED LIGHT

Cystoliths.—These amorphous calcium carbonate deposits present the appearance of white granular aggregates in the dark field of crossed prisms. In water mounts of powders containing cystoliths there is sometimes a purplish tinge to the mass; this coloration is more pronounced when they are viewed with an instrument in which the analyzer has been substituted for the usual condenser. Crystoliths if very thick will extinguish under crossed prisms.

Specimens examined: Powdered cannabis indica and ruellia; sections of cannabis indica leaf, ficas leaf and ruellia.

Inulin.—Fragments of this substance appear as white masses in the dark field. Neither coloration nor characteristic markings were observed.

Specimens examined: Powdered inula, araxacum and lappa; sections of taraxacum and lappa.

Aleurone.—Cells containing this substance become entirely dark or completely extinguish under crossed prisms.

Specimens examined: Powdered fenugreek and mustard; sections of mustard.

Oil globules.—The globules of volatile oil in the specimens examined totally extinguish in the dark field.

Specimens examined: Powdered cubeb, pepper and mustard.

Crystals.—It is difficult to apply principles of optical or chemical crystallography to the crystalline deposits of calcium oxalate occurring in plants, because of the many transition forms and fragments present. The location of a perfect crystal in vegetable powders is rather the exception. The crystals of senna and cascara, which the vegetable histologist would without hesitation classify as cubical, in a majority of instances do not react to polarized light as isometric or cubic crystals should. Isometric crystals are classed with the isotropic bodies and should not undergo change during rotation of the prisms. Most so-called cubic crystals in plant tissues would be classified by the crystallographic worker as anisotropic bodies by reason of the changes occurring during rotation of the prisms. This apparent lack of agreement with laws of crystal formation in the case of these cubic crystals may be due to limitations of crystal growth by the cell membranes in the living plant. In powdered drugs it might be occasioned by partial fracture of the crystals during grinding. All plant crystals undergo more or less coloration during rotation of the prisms. Coloration is most pronounced in the case of the acicular and the larger prismatic crystals. In the dark field, prismatic crystals usually exhibit several black bands running parallel with the visible outer boundaries of the crystal. Cubic crystals usually show one black band parallel with the visible boundaries. The acicular, rosette and microcrystals may or may not show coloration in the dark field.

Specimens examined: Powdered senna, licorice, frangula, cascara, quillaja, sarsaparilla, belladonna, squill, rhubarb, castanea, polygonatum and quebracho; sections of sarsaparilla, licorice, cascara, belladonna, phytolacca and rhubarb.

Starch.—The main characters to be observed in the examination of starches by polarized light are striations, positions of the crossed lines in the light and dark fields, and comparative width of the arms of the crossed lines. These cross lines are characteristic of all starches. The intersection point of the lines is always through the hilum or anatomical center of the grain. The outline of the cross depends to considerable extent upon the outline of the grain. The width of the angle formed by the cross lines and the relative widths of the arms appear to be fairly constant for each starch. As starches of botanically related drugs show similarities in the shape and formation of the hilum, so do their polarization figures agree. When the prisms are slowly rotated, the cross lines follow the rotation, and sections of the grain which were white under crossed prisms will assume a dark color; the cross lines under these conditions will be outlined in white. Striations appear to be accentuated when viewed by polarized light. In granules having an oval outline, the polarization figure always extends in the direction of the long axis. If the grain is spherical the arms of the figure are usually equidistant from each other and their point of intersection is in the center, corresponding with the hilum. Water mounts will show to best advantage, although permanent mounts may be used.

Specimens examined: Wheat, rye, corn, barley, maranta and potato starches, aconite, hydrastis, cimicifuga, sarsaparilla, colchicum, galangal and iris starches.

Mucilage cells.—Materials to be examined for mucilage are best mounted in glycerin, as an aqueous medium may affect the mucilage deposits. This substance when viewed by polarized light gives effects similar to those observed in the examination of spherical starch grains. The arms of the cross lines are equidistant from each other and always at right angles. The figure is that of a maltese cross. The cross lines change from light to dark upon rotation. Under polarized light in the dark field, the mucilage sacs of powdered mustard are readily visible even in the very thick mounts.

Specimens examined: Powdered mustard and ulmus.

Resins and gum resins.—None of the resins or gum resins examined exhibited characters of note when viewed by polarized light. The resin masses in the powdered drugs examined extinguish under crossed prisms.

Specimens examined: Powdered jalap, sanguinaria, serpentaria, gamboge, myrrh.

In summarizing we may conclude that the polarizing apparatus is of value in determining minute structural details which in many instances would otherwise escape observation. In sections where the cells are in such close proximity that intercellular space is apparently lacking and cell-walls appear to be continuous, the actual details may be easily and rapidly determined by the apparatus. The writer has found polarized light a readily applied and certain aid in micro-analyses involving determinations of starches, crystals, fibers and mucilage-sacs.

*From the *Druggists Circular*.

A Useful Movement

THE British Board of Trade issues from time to time small handbooks dealing with the trades of the principal manufacturing centers, designed especially for the use of advisory committees for juvenile employment. Some of the subjects treated of in these books are brazing, blacksmithing in connection with coach building, metal spinning, the electrical trades, gun making, safe and lock making, and a number of other employments.

The Share of Egg and Sperm in Heredity

By Edwin G. Conklin, Department of Biology, Princeton University

1. Assumed Equivalence of Inheritance from Both Parents.—Practically all students of heredity are agreed that there is a general equivalence of inheritance from father and mother, and O. Hertwig (1892) cites this as one of the evidences that the chromosomes only contain inheritance material, or 'Erbmasse,' since they alone come in approximately equal volumes from the two parents. Indeed phenomena of Mendelian inheritance demonstrate that, with respect to those characters which usually distinguish the two parents, there is equivalence of inheritance from each, and where offspring resemble one parent more than the other they are probably as frequently patroclinous as matroclinous. Furthermore, the distribution of chromosomes in maturation, fertilization and cleavage is exactly parallel to the distribution of Mendelian factors, which practically demonstrates that the chromosomes are the seat of these factors.

This conclusion has led many students of heredity to regard the cytoplasm of the germ cells as of no significance in heredity. Both egg and sperm contain cytoplasm which is differentiated, in the former for the nutrition of the embryo, in the latter for bringing the sperm into union with the egg; but in neither case is this differentiated cytoplasm directly concerned in heredity. The highly differentiated cytoplasm of the spermatozoon is either left outside the egg when its nucleus enters, or it undergoes de-differentiation within the egg; at the same time the egg cytoplasm ceases to form yolk, while the yolk which has been formed is gradually used up in the nourishment of the embryo. Consequently since these particular differentiations of the germ cells disappear after the union of egg and sperm it has been generally supposed that all cytoplasmic differentiations of these cells are wiped out at this time, and that the first differentiations of the new individual begin at the moment of fertilization in a wholly undifferentiated cytoplasm.

In the higher animals at least most of the cytoplasmic differentiations of the spermatozoon are lost after it enters the egg, though some differentiations such as centrosome, plastosomes and archplasm may persist; however there is the most positive evidence that many differentiations of the egg cytoplasm persist and play an important part in embryonic differentiation.

2. Egg Differentiations which persist in Embryo and Adult.—(*A*) *Polarity.* The polarity of the egg invariably determines the polarity of the embryo and adult. In all animals the chief axis of the egg becomes the chief axis of the gastrula, and this becomes the chief axis of the adult in sponges and coelenterates (protaxonia), or, as in all other metazoa (heteraxonia), this axis is bent on itself by the greater growth of the gastrula on its posterior side so that the chief axis of the adults is a modification of the gastrular axis. In either case the polarity of the unfertilized egg determines the localization of the developmental processes and ultimately the polarity of the developed animal.

(*B*) *Symmetry.* In most animals the egg is spherical in shape and appears to be radically symmetrical, nevertheless observation and experiment show that such eggs are sometimes bilateral, as is probably the case in Amphioxus, ascidians, fishes and frogs. In the case of the frog's egg it was long believed that the plane of bilateral symmetry was determined wholly and exclusively by the path of the spermatozoon within the egg; more recently it has been shown by Brachet (1911) that primary bilateral symmetry is present before fertilization, though after fertilization the plane of symmetry may be shifted into the path of the spermatozoon. It is probable that all bilateral animals come from eggs which show a similar primary bilaterality and that this differentiation precedes fertilization. In cephalopods and some insects all the axes and poles of the developed animal are already recognizable in the egg before fertilization. Symmetry, therefore, as well as polarity is derived from the egg and not from the sperm.

(*C*) *Inverse Symmetry* (*Asymmetry*). In many animals the right and left sides of the body are not completely alike, and this is especially true of internal organs. This asymmetry is especially well developed in gasteropods in which certain organs of one side of the body are entirely lacking; some species or individuals have these asymmetrical organs on one side, others on the other side and correspondingly the snail shell coils in a clock-wise direction in one case, an anticlock-wise direction in the other. It was discovered by Crampton (1894) and Kofoid (1894) that in sinistral species the direction of certain cleavages of the egg (*viz.* the third to the sixth) was the reverse of the corresponding cleavages in dextral species and Conklin (1903) showed that the first and second cleavages also were in opposite directions in dextral and sinistral snails. Consequently the "inverse symmetry" of these snails may be traced back through the later and earlier cleavage stages to the unsegmented egg itself which is inversely symmetrical in sinistral as compared with dextral forms.

(*D*) *Types of Egg Organization.*—The polar differentiation of an egg is manifested particularly in the localization of different kinds of materials in different parts of the egg. These materilas may be inert pigment or yolk, but their localization by the activity of the cytoplasm indicates a definite pattern of organization in the cytoplasm. This pattern of egg cytoplasm differs greatly in certain phyla, there being a coelenterate type, an echinoderm type, an annelid-mollusk type. and a chordate type. The type of egg organization foreshadows the type of adult organization; in ascidians for instance distinct cytoplasmic substances are found in the egg in the same realtive positions and proportions as the ectoderm, endoderm, mesoderm, notochord and nervous system of the embryo.

That the fundamental pattern of egg cytoplasm is not influenced by the spermatozoon is proved by the following facts:

a. It exists before fertilization, or it appears so soon after that it could not have been caused by the sperm.

b. In heterogeneous fertilization the pattern of the egg is not changed by the foreign sperm.

c. Natural or artificial parthenogenesis demonstrates that this pattern exists in the absence of fertilization.

These as well as other facts such as the correspondence between the size of the egg and the size of the embryo (Morgan); the transmission of chromatophores and peculiarities of leaf coloration by the female and not by the male germ cells in plants (Baur, Shull); the transmission in the egg cytoplasm of fat stains, chemical substances, immunizing bodies and possibly parasites prove that, "at the time of fertilization the hereditary potencies of the two germ cells are not equal, all the early development, including the polarity, symmetry, type of cleavage, and the relative positions and proportions of future organs being predetermined in the cytoplasm of the egg cell, while only the differentiations of later development are influenced by the sperm. In short, the egg cytoplasm fixes the type of development and the sperm and egg nuclei supply only the details" (Conklin 1908).

Ontogeny begins with the differentiation of the egg in the ovary and not at the moment of fertilization; at the latter time some of the most general and fundamental differentiations have already occurred. Indeed the cytoplasm of the egg is the more or less differentiated body of the embryo.

3 Is Inheritance through the Egg Cytoplasm Non-Mendelian?—Whenever a character is transmitted as such through the egg cytoplasm and not as factors in the chromosomes of egg and sperm it is not inherited in Mendelian fashion. Thus if chromatophores are transmitted from generation to generation in the cytoplasm of the egg and are at no time influenced by the sperm, their mode of inheritance is non-Mendelian. If the polarity, symmetry and pattern of the egg do not arise during oogenesis, but are carried over unchanged from generation to generation they are also non-Mendelian characters. With regard to the polarity of the egg, it is not certain whether it is transmitted in this manner or not; but its symmetry and pattern of organization are evidently developed anew in each generation. It is a significant fact that in oogonia and spermatogonia the volume of the nucleus is sometimes greater than that of the cytoplasm, and in all cases it is relatively greater in early stages of the genesis of the sex cells than in later ones. In general the relative volume of nucleus and cytoplasm is a good measure of the differentiation of the latter. Most of the cytoplasmic differentiations of the egg and sperm arise during the genesis of those cells, just as in the case of tissue cells. Nerve cells and muscle cells differentiate under the influence of maternal and paternal chromosomes, and undoubtedly the same is true of most of the differentiations of egg and sperm; but while some of these egg differentiations persist in the new individual those of the sperm do not. Consequently, in each generation the egg contributes more than the sperm to ontogeny. There is cytoplasmic inheritance through the female only, but these cytoplasmic characters are themselves of biparental origin.

This is Mendelian inheritance though somewhat complicated by the fact that every ontogeny has its beginning in the preceding generation. Therefore, the conclusion which I recently expressed (Conklin 1916) *viz.*, that polarity, symmetry and pattern of egg organization are non-Mendelian characters, is not justified.

Somewhat similar phenomena have been described by McCracken (1909); and Toyama (1913) in silk worms and by several authors (Locke, Castle, *et al*) in the seed characters of maize, wheat, etc. McCracken found that when two races of the silk worm are crossed one of which produces one brood a year (univoltin) and the other two (bivoltin), the F_1 offspring are all like their mother and in the F_2 generation "the broods fail to follow both parents in the expected proportions. Therefore," she concludes, "the Mendelian law does not hold in this case." Castle (1910) has criticised this conclusion and has explained these results on the ground that voltinism is inherited through the egg and that univoltinism is a Mendelian dominant to bivoltinism. Toyama (1913) has described in detail the mode of inheritance of several egg characters of silk worms and has shown that whereas these seem to be non-Mendelian they are in reality Mendelian, "the cause of disturbance of the proper order being due to the fact of maternal inheritance, in which paternal characteristics remain dormant, even though dominant in the egg stage."

Brachet, A., *Arch. biol. Paris-Bruxelles*, 26, 1911 (337-364).
Castle, W. E., *J. Exp. Zool.*, 8, 1910 (185-192).
Conklin, E. G., *Anat. Anz., Jena*, 23, 1903 (577-588); *Science, New York*, 27, 1908 (89-99); *Heredity and Environment*, 2d Ed., Princeton, 1916.
Crampton, H. E., *Ann. N. Y. Acad. Sci.*, 1894 (167-169).
Hertwig, O., *Zelle und Gewebe*, Jena, 1892 (1-296).
Kofoid, C. A., *Boston, Proc. Amer. Acad. Arts. Sci.*, 29, 1894.
McCracken, I., *J. Exp. Zool.*, 7, 1909 (747-764).
Toyama, K., *J. Genetics*, 2, 1913 (351-405).

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